Method 2: Acknowledgement via LED reset

- An LED reset (device) causes the reset of all stored LEDs and binary output contacts of the device and also to the confirmation of all fault displays stored in the display.

You can find more details on the topic of LED reset in chapter 3.1.9 Stored Indications in the SIPROTEC 5 Device.

3.1.9 Stored Indications in the SIPROTEC 5 Device

In your SIPROTEC 5 device, you can also configure indications as stored. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged. Acknowledgment occurs via:

- On-site operation panel
- DIGSI 5
- Binary input
- Protocol of substation automation technology

Configuration of Stored Indications with DIGSI 5

- In the Information Routing of each device set up in DIGSI 5, you can route binary signals, among others, to LEDs and output contacts. For this, go to the project tree.
  Project → Device → Information routing
- Right-click the routing field of your binary indication in the desired LED or binary output column in the routing range of the targets.

You are offered the following options:

Table 3-4 Overview of Routing Options

Routing Options		LEDs	BOs	BIs	Description
H	(active)			X	The signal is routed as active with voltage.
L	(active)			X	The signal is routed as active without voltage.
U	(unlatched)	X	X		The signal is routed as unlatched. Activation and reset of the output (LED, BO) occurs automatically via the binary signal value.
L	(latched)	X	X		The binary signal is latched when the output (LED) is activated. To reset, a targeted confirmation must occur.
NT	(stored only with tripping)	X			Fault indications are stored when the output (LED) is activated. If the fault is ended via a trip command from the device, the stored state is maintained. In case of dropout of the pickup without trip command from the device (for example, external fault), the state displayed before the fault is restored. Note: Observe here the parameter (_:91:139) Fault-display with the setting options with trip or with pickup. For this routing option, select the setting with trip.

Routing Options		LEDs	BOs	BIs	Description
TL	(stored only with tripping)		X		Routing option TL (tripping stored) is only possible for the switching object circuit breaker. The output is saved with protection tripping. The contact remains activated until acknowledged. Control commands are not affected. A control command is pending above the parameterized command period until feedback has been successfully received. Note: You can realize the functionality of the Lockout (ANSI 86) by storing the output relay with the routing option TL.

Acknowledgment of Stored Indications on the On-Site Operation Panel

Acknowledgment via LED Reset

Operating the button first causes the activation of all LEDs (LED test) when pressed, and when released the resetting of all stored indications. Stored LEDs, output contacts and spontaneous fault displays are reset.

Acknowledgment via the operating menu

Use the navigation buttons at the on-site operation panel, in order to reach the reset functions from the main menu.

- Select: Main menu → Device functions → **Reset functions**
  You are offered different reset options.
- Open the corresponding submenu.

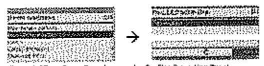

Figure 3-27 Reset Functions on the On-Site Operation Panel

- Use **Res. binary outputs** to reset stored output contacts.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.
- Use **Reset LEDs not in FG** to reset stored LEDs that are not assigned to a special function group.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.

Depending on device configuration, the protection function group(s) are displayed to you as submenus for which separately corresponding, stored LEDs can be reset.

- Go to the submenu of the selected function group (example Line 1).
- Use **Reset LEDs** to reset stored LEDs in the selected function group.
- Actuate the softkey **Start** in the base bar.
- As needed, enter the confirmation ID when requested and then confirm with the softkey **Enter**.

Figure 3-28 Reset Functions on the On-Site Operation Panel (for Example, Line FG)

Acknowledgment of Stored Indications via Binary Inputs

Acknowledgment via binary >LED Reset

Acknowledgment via binary input >LED-Reset brings about the activation of all LEDs (LED test) and, in case of dropout of signal, the resetting of all stored indications. Stored LEDs, output contacts and spontaneous fault displays are reset.

Acknowledgment of Stored Indications with DIGSI 5

You can acknowledge stored indications via DIGSI 5 in online mode. For this, go to the project tree.

- Select Online access → Interface → Device → **Device information**

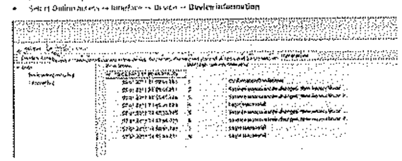

Figure 3-29 LED Reset via DIGSI 5

- Click the LED reset button.
- Enter the confirmation ID.
- Confirm the process with OK.

Stored LEDs, output contacts and spontaneous fault displays are reset on the assigned device.

Acknowledgment of Stored Indications via Log

Initiation of acknowledgment of stored indications can also occur through communication via a connected substation automation technology. This can occur in conformance to standards (IEC 61850, IEC 60870-5-103) or via configuration (mapping) of the LED reset input signal for any protocol. Stored LEDs, output contacts, and spontaneous fault displays are reset.

> **NOTE**
>
> The acknowledgment of stored indications then leads to the resetting of configured LEDs and output contacts, as long as these active unstored indications are not present in parallel. That is, indications configured as unstored are not affected by the acknowledgment process.

3.1.10 Test Mode and Influence of Indications on Substation Automation Technology

If the test mode of the device or of individual functions is switched on, the SIPROTEC 5 device marks indications sent to substation automation technology station control system with an additional test bit. This test bit makes it possible to determine that an indication was set during a test. Necessary reactions in normal operation on the basis of an indication can thus be suppressed.

3.1.11 Resetting Stored Indications of the Function Group

You can configure indications of individual functions as "stored" in a function group. This type of configuration can be used for LEDs as well as for output contacts. The configured output (LED or contact) is activated until it is acknowledged.

The protection and the circuit-breaker function groups contain the block **Reset LED FG**. The block **Reset LED FG** is visible only in the information routing under the corresponding function group in DIGSI 5. You use the binary input signal *>Reset LED* to reset the stored LEDs in the respective function group. The configured outputs (contacts) are not reset.

3.2 Measured-Value Acquisition

Basic Principle

SIPROTEC 5 devices are equipped with a powerful measured-value acquisition function. In addition to a high sampling frequency, they have a high measurand resolution. This ensures a high degree of measuring accuracy across a wide dynamic range. The 24-bit sigma/delta analog-digital converter represents the core of measured-value acquisition. In addition, the oversampling function supports the high measurand resolution. Depending on the requirements of the individual method of measurement, the sampling frequency is reduced (Downsampling).

In digital systems, deviations from the rated frequency lead to additional errors. In order to avoid this, 2 algorithm-dependent processes are used in all SIPROTEC 5 devices:

- Sampling frequency tracking:
  The analog input channels are scanned for valid signals in cycles. The current power frequency is determined and the required sampling frequency is defined by using a resampling algorithm. The tracking is effective in the frequency range between 10 Hz and 80 Hz.
- Fixed sampling frequency – correction of the filter coefficients:
  This method operates in a limited frequency range (f_{rated} +/- 5 Hz). The power frequency is determined and, depending on the degree of the frequency deviation, the filter coefficients are corrected.

The following figure shows the basics of dealing with sampled values (SAV) in the measured-value acquisition chain. Figure 3-30 shows to whom the various sampling frequencies are made available. In order to limit the bandwidth of the input signals, a low-pass filter (anti-aliasing filter to maintain the sampling theorem) is installed downstream. After sampling, the current input channels are adjusted. This means the magnitude, phase, as well as the transformer time constant are corrected. The compensation is designed to ensure that the current transformer terminal blocks can be exchanged randomly between the devices.

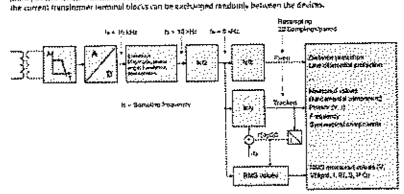

Figure 3-30 Measured-Value Acquisition Chain

The internal sampling frequency of the SIPROTEC 5 devices is fixed at 16 kHz (sampling rate: 320 samplings per 50-Hz cycle). All current and voltage inputs are sampled. If the magnitude, phase, and transformer time constant are corrected, the sampling frequency is reduced to 8 kHz (160 samplings per 50-Hz cycle). This is the basic sampling frequency to which various processes, such as fault recording, RMS measured values, refer. For the RMS measurement, the measured value window is adjusted on the basis of the power frequency. For numerous measurements and protection applications, 20 samplings per cycle are sufficient (if f_{rated} = 50 Hz sampling every 1 ms, at f_{rated} = 60 Hz sampling every 0.833 ms). This sampling rate is an adequate compromise between accuracy and the parallel processing of the functions (multi-functionality).

The 20 samplings per cycle will be made available to the algorithms processed in the function groups, in 2 variants:

- Fixed (not resampled)
- Resampled (frequency range from 10 Hz to 80 Hz)

Depending on the algorithms (see function descriptions), the respective data flow is considered. A higher sampling frequency is used for selected methods of measurement. Detailed information can be found in the corresponding function description.

> **NOTE**
>
> The measuring points for current and voltage are in the Power-system data (starting in chapter 6.1 Power System Data). Each measuring point has its own parameters.

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3.3 Processing Quality Attributes

3.3.1 Overview

The IEC 61850 standard defines certain quality attributes for data objects (DO), the so-called Quality. The SIPROTEC 5 system automatically processes some of these quality attributes. In order to handle different applications, you can influence certain quality attributes and also the values of the data objects on the basis of these quality attributes. This is how you can ensure the necessary functionality.

The following figure describes roughly the general data flow within a SIPROTEC 5 device. The following figure also shows at which points the quality can be influenced. The building blocks presented in the figure are described in more detail in the following.

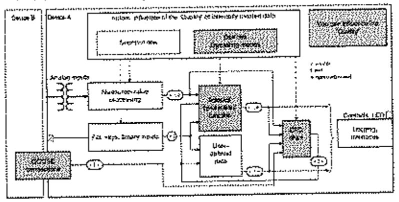

Figure 3-31 Data Flow within a SIPROTEC 5 Device

Supported Quality Attributes

The following quality attributes are automatically processed within the SIPROTEC 5 system.

- Validity using the values *good* or *invalid*
  The Validity quality attribute shows if an object transferred via a GOOSE message is received (valid, invalid) or not received (invalid). The *invalid* state can be suppressed in the receiver device by also setting a substitute value for the object that is not received (see Figure 3-32). The substitute value is forwarded to the functions.
  If the device receives one of these values, it is replaced by the *invalid* value and thus processed further as *invalid*.
  If one of the detailed quality attributes (detailQual) has the value *TRUE*, then Validity is set to the *invalid* value, unless this was already done at the transmitter end.
- Test using the values *TRUE*, *FALSE*
  The Test quality attribute indicates to the receiver device that the object received via a GOOSE message was created under test conditions and not operating conditions.

- OperatorBlocked using the values *TRUE*, *FALSE*
  The OperatorBlocked quality attribute indicates whether an object transferred via a GOOSE message originates from a device that is in a *functional logoff* state. When the sending device is switched off, the object is no longer being received and assumes the *invalid* state. However, since the OperatorBlocked quality was previously identified on the receiver device, the object can be treated differently at the receiving end (see chapter 3.3.2 Quality Processing/Affected by the User for Received GOOSE Values). At the receiving end, the object may be treated like a retained signal.
- Source using the values *process*, *substituted*
  The Source quality attribute indicates whether the object was updated in the sending device.
  You can find more detailed information in chapter 3.8.7 Acquisition Blocking and Manual Updating.

Influencing Quality by the Operating Modes

In addition to the normal operation, the device also supports further operating modes that influence quality:

- Test mode of the device
  You can switch the entire device to test mode. In this case, all data objects generated in the device (state values and measured values) receive the quality attribute Test = *TRUE*.
  The CFC charts are also in test mode and all output data receive the quality attribute Test = *TRUE*.
- Test mode for individual functions, stages, or function blocks
  You can switch individual functions, stages, or function blocks into test mode. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute Test = *TRUE*.
- Functional logoff of the device
  If you take the device out of operation and want to isolate it from the supply voltage, you can functionally log off the device ahead of time. Once you functionally log off the device, all data objects generated in the device (state values and measured values) receive the quality attribute OperatorBlocked = *TRUE*. This also applies to the output from CFC charts.
  If objects are transferred via a GOOSE message, the receiver devices can assess the quality. The receiver device detects a functional logoff of the transmitting device. After shutting down the sending device, the receiver device identifies that the sending device has been logged off operationally and did not fail. Now the receiving objects can automatically be set to defined states (see chapter 3.3.2 Quality Processing/Affected by the User for Received GOOSE Values).
- Switching off individual functions, stages, or function blocks
  You can switch off individual functions, stages, or function blocks. In this case, all data objects generated by the function, stage, or function block (state values and measured values) receive the quality attribute Validity = *invalid*.

Influencing the Quality through Hardware Supervision

Supervision functions monitor the device hardware (see chapter 8.4 Supervision of the Device Hardware). If the supervision functions identify failures in the data acquisition of the device, all recorded data will receive the quality attribute Validity = *invalid*.

Influencing the Quality through Voltage-Transformer Circuit Breakers

If tripping of the voltage transformer circuit breaker is detected (see chapter 8.3.4 Voltage-Transformer Circuit Breaker), all recorded data will receive the quality attribute Validity = *invalid*.

Influencing the Quality by the User

You can influence the processing of data and their quality differently. In DIGSI 5, this is possible at the following 3 locations:

- In the information routing editor for external signals of GOOSE connections
- In the CFC chart
- In the information routing editor for binary input signals of device-internal functions

The following chapters describe in more detail the options regarding the influence as well as the automatic quality processing.

If a GOOSE connection is the data source of a binary input signal of a device-internal function, you can influence processing of the quality at 2 locations: at the GOOSE connection and at the input signal of the function. This is based on the following: A GOOSE date can be distributed within the receiving device to several functions. The GOOSE connection setting (influence) affects all functions. However, if different functions require customized settings, these are then set directly at the binary input signal of the function.

3.3.2 Quality Processing/Affected by the User for Received GOOSE Values

In the Information Routing editor, you can influence the data value and quality of all data types. The following figure shows the possible influence using the example of an DPC data type.

- In the DIGSI 5 project tree, double-click **Information Routing**.
- Select the desired signal in the External Signals group.
- Open the **Properties** window and select the **Processing Quality Attributes** sheet.

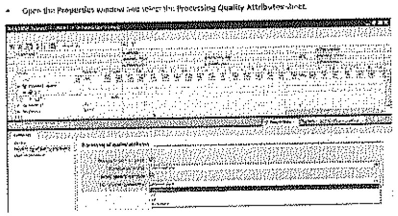

Figure 3-32 Influence Option When Linking an DPC Type Data Object

The setting options work for the device receiving the data.

Quality Attribute: Validity	
The validity values *reserved* and *questionable* are replaced at the receiving end by the *invalid* value.	
• Check box is not set. • Check box is set and receipt of Validity = *good*	The validity attribute and data value are forwarded without change.
Check box is set and receipt of Validity = *invalid* is set (also applies to values *reserved* and *questionable*).	• The validity attribute is set to *good* and processed further using this value. • The data value is set to the defined substitute value and processed further using this substitute value.

Quality Attribute: OperatorBlocked (opBlk)	
• Check box is not set. • Check box is set and received OperatorBlocked = *FALSE*	The OperatorBlocked attribute and data value are forwarded without change.

Quality Attribute: OperatorBlocked (opBlk)	
Check box is set and received OperatorBlocked = *TRUE*	• The OperatorBlocked attribute is set to *FALSE* and processed further using this value. • The data value is set to the defined substitute value and processed further using this substitute value.

Interaction of the Quality Attribute Validity and OperatorBlocked	
OperatorBlocked check box is set and receipt of OperatorBlocked = *TRUE*	Regardless of whether the validity check box is set or not, and regardless of the current validity, the validity attribute is set to *good* and the substitute value of the OperatorBlocked data object is set. That is, the OperatorBlocked settings overwrite the Validity settings.
OperatorBlocked check box is not set and receipt of OperatorBlocked = *TRUE*	The OperatorBlocked attribute remains set and is forwarded. If the Validity check box is set and the receipt of validity = *invalid* is set, the respective data object substitute value is used. For continued signal processing and influence, it must be taken into account that in this configuration the data object substitute value for validity = *invalid* is set, but the quality attribute OperatorBlocked is not yet set.

Data Substitute Values

Depending on the data type, different data substitute values must be used.

Data Type	Possible Data Substitute Values	
ACD, ACT	general, phsA, phsB, phsC, neut	0 (False), 1 (True)
only ACD	dirGen	0, 1, 2, 3 (Unknown, Forward, Backward, Both)
	dirPhsA, dirPhsB, dirPhsC, dirNeut	0, 1, 2 (Forward, Backward, Both)
BAC, APC	mxVal	1.401298 · 10^{-45} to 7.922 · 10^{28}
	stSeld	0 (False), 1 (True)
	ctlNum	1 to 255
BCR	actVal, frVal, frTm	0 to 1 073 741 824
CMV	mag, ang	1.401298 · 10^{-45} to 7.922 · 10^{28}
DPC, DPS	stVal	0, 1, 2, 3 (intermediate-state, off, on, bad-state)
Enum types (for example, ENS, ENI, ENC)	SPS output	0 (False), 1 (True)
	DPS output	The qualities of the object of the sending device are taken on.
INC	stVal	0 to 1 073 741 824
	stSeld	0 (False), 1 (True)
INS	stVal	0 to 1 073 741 824
INS	stVal	0 to 1 073 741 824
ISC, BSC	valWTr.posVal	-64 to 64
	valWTr.transInd	0 (False), 1 (True)
SEC	cnt	0 to 1 073 741 824
SPC, SPS	stVal	0 (False), 1 (True)
SPG	setVal	0 (False), 1 (True)

Data Type	Possible Data Substitute Values	
MV	mag	1.401298 · 10^{-45} to 7.922 · 10^{28}

3.3.3 Quality Processing/Affected by the User in CFC Charts

In DIGSI 5, you can control the quality processing of CFC charts. In the project tree, you can find the CFC block (see the following figure) under **Device name** → **Settings** → **Device settings** in the editor.

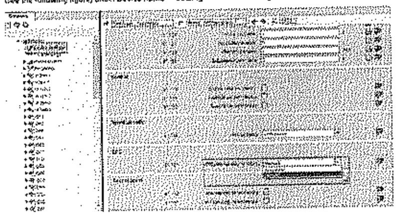

Figure 3-33 Influencing CFC Quality Handling in DIGSI 5

With the CFC chart quality handling parameter, you control whether you want to influence the quality of CFC charts in a *Manual* or *Automatic* (default setting) manner.

If you select *Manual*, the quality attribute of the CFC chart is always valid regardless of the quality of individual signals (Validity = good)!

Only the Test quality attribute of the CFC chart is processed. If the device is in test mode or the input TEST of the CHART_STATE CFC block is set, the quality attribute of the CFC chart is set to **Test**.

If you select *Automatic*, the quality processing of the CFC charts is influenced as follows:

In the case of CFC charts, a distinction has to be made between the general quality processing and certain CFC blocks that are specifically designed for quality processing.

General Processing

Most of the CFC blocks do not have an explicit quality processing. For these blocks, the following general mechanisms shall apply.

Quality Attribute: Validity
If one *invalid* signal is received in the case of CFC input data, then all CFC output data will also be set to *invalid* if they originate from building blocks without explicit quality processing. In other words, the quality is not processed sequentially from building block to building block but the output data are set globally. This does not apply to CFC output data that originate from building blocks with explicit quality processing (see next section).

Quality Attribute: Test	
CFC chart is in normal state.	CFC input data with the Test = *TRUE* attribute are ignored. When the CFC chart is executed, then the data value that was used before the Test = *TRUE* attribute is used. The quality of this old value is also processed. This means that on the output side, the attribute Test = *FALSE*.
CFC chart is in Test[1] state.	If the CFC chart is executed, then the attribute Test = *TRUE* is set for all data leaving the CFC chart. This does not depend on whether the data are routed via CFC blocks with or without quality processing.

[1] A CFC chart can be switched to the test state by switching the entire device to test mode or the input TEST of the CFC block CHART_STATE is set.

Quality Attribute: OperatorBlocked	
CFC chart is in normal state.	In CFC charts for incoming data, the OperatorBlocked attribute is ignored.
CFC chart is in functionally logged off[2] state	In CFC charts for incoming data, the OperatorBlocked attribute is ignored. All CFC output data are labeled as functionally logged off.

[2] This state only occurs if the device is functionally logged off. In this case, the quality attributes of all CFC outputs are labeled as functionally logged off.

Quality Processing Building Blocks (Condition Processing)

The first 3 blocks (x_SPS) process the quality automatically according to the stated logic. The other blocks are used to isolate the quality from a data object and add them back after separate logical processing.

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Building Blocks	Description
OR_SPS AND_SPS NEG_SPS	The blocks also process the supported quality attribute according to their logic. The following tables describe the logic depending on the input values in connection with the quality attribute Validity. The input values are 0 or 1, the quality attribute Validity can have the value *good* (=g) or *invalid* (=i). x = placeholder for the input value and quality attribute Validity

OR_SPS

A (Value, Attribute)	B (Value, Attribute)	Q (Value, Attribute)
0, i	0, x	0, i
0, g	0, g	0, g
1, g	x, x	1, g
1, i	0, x	1, i
1, i	1, x	1, i

The output thus has the logical value 1 with Validity = *good* as soon as at least 1 input has the logical value 1 with Validity = *good*. Otherwise, the inputs are treated according to the OR operation and the INVALID bit is OR-gated for the quality.

AND_SPS

A (Value, Attribute)	B (Value, Attribute)	Q (Value, Attribute)
0, g	x, x	0, g
0, i	1, x	0, i
1, i	1, x	1, i
1, g	1, g	1, g

The output thus has the logical value 0 with Validity = *good* as soon as at least 1 input has the logical value 0 with Validity = *good*. Otherwise, the inputs are treated according to the AND operation and the INVALID bit is OR-gated for the quality.

NEG_SPS

A (Value, Attribute)	Q (Value, Attribute)
0, i	1, i
0, g	1, g
1, i	0, i
1, g	0, g

Building Blocks	Description
SPLIT_SPS SPLIT_DPS SPLIT_XMV	The blocks isolate the data value and quality of a data object. The requirement is that the quality is available from the input end. This is the case if the block is interconnected with CFC input data, or is connected downstream with a quality processing building block (x_SPS). In other cases, the CFC editor does not allow a connection.
SPLIT_Q	The block performs binary separation of the quality into *good*, *bad* (= *invalid*), *test*, *off* and *OperatorBlocked*. These 5 attributes can then be processed individually in a binary operation. The block must be connected downstream to a SPLIT_(DO) block.
BUILD_Q	The building block enters a binary value for *good* and *bad* (= *invalid*) in each quality structure. Thus, with this building block the quality attributes *good* and *bad* (= *invalid*) can be set explicitly, for example, as the result of a monitoring logic. All other quality attributes are set to the default state, for instance, Test = *FALSE*. If, for example, the entire CFC chart is in the test state (see Quality Attribute: Test Under General Processing), this default status can again be overwritten on the CFC output side. The building block is normally connected downstream to a BUILD_(DO) building block.

Building Blocks	Description
BUILD_ACD BUILD_ACT BUILD_BSC BUILD_DPS BUILD_ENS BUILD_SPS BUILD_XMV	These blocks merge data value and quality. The block output is generally wired to a CFC output. Generally, the BUILD_Q block is connected upstream from these building blocks.

CFC charts have a standard behavior in the processing of signals. If an input signal of the CFC chart has the quality *invalid*, all output signals of the CFC chart also get the quality *invalid*. This standard behavior is not desirable in some applications. If you use the building blocks for quality processing, the quality attributes of the input signals in the CFC chart are processed.

EXAMPLE: Switchgear Interlocking via GOOSE

The following conditions apply to the example:

- The interlocking condition for switchgear interlocking protection is stored in the device as a CFC chart.
- The remote device sends the release signal for the interlocking condition via a GOOSE telegram.

If the communication connection has been interrupted, the release signal (GOOSEStr) incoming via the GOOSE telegram gets the quality *invalid*. If the CFC chart obtains an invalid input signal, there are the following possibilities. The last signal valid before the communication interruption is used (quality = *good*) or a substitute data value with the quality *good* is used (True, False).

To do this, you have to create a separate CFC chart in addition to the interlocking plan of the switchgear interlocking. Use the building blocks for quality processing in a separate CFC chart. With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. You can then continue to process these signals separately in the CFC chart. Use the quality information as an input signal for a BUILD_SPS building block and assign the quality *good* to the signal. You obtain an SPS signal as a result, with the quality *good*. You can use this to process release messages correctly. You can process the release messages with the quality *good* in the CFC chart of the actual interlocking. Therefore, the release signal for a switch illustrated in the interlocking logic is available as a valid result with the quality *good*. The following figure shows an example of the CFC chart with the building blocks for quality processing.

Figure 3-34 CFC Chart with Building Blocks for Quality Processing (Switchgear Interlocking via GOOSE)

If you do not want to convert the invalid release signal to a valid signal, as described, during the communication interruption, you can also assign a defined data value to the release signal. Proceed as follows: With the SPLIT_SPS building block, split the input signal (data type = SPS) into data value and quality information. Link the VALID output of the SPLIT_SPS building block with the data value of the input signal (AND gate). This way, you can set the value to a defined state with the valid input signals. In the example, the output of the CFC chart is set to the value *FALSE* when the input signal is invalid.

3.3.4 Quality Processing/Affected by the User in Internal Device Functions

Figure 3-35 provides an overview for processing the quality of data objects within a device-internal function. A function can receive internal data or input data that is routable by the user (binary input signals or double commands). The respective quality attributes supported are evaluated by the function on the input side. The attributes are not passed through the specific algorithm/the specific logic of the function. The output data are supplied with a quality that is specified by the function state and device-operating mode.

> **NOTE**
> Take into account that pickup of chatter blocking (see chapter 3.8.5 Signal Filtering and Chatter Blocking for Input Signals) sets the corresponding Validity attribute to *invalid*.

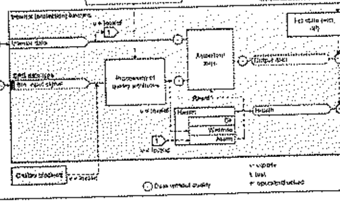

Figure 3-35 Overview for Processing Quality within an Internal Function

Internal Input Data

The quality processing is automatic for internal input data.

Supported Quality Attributes	Description
Validity	• At the receiving end, internal values can only be *invalid* or *good*. • If *invalid*, the function health is set to Alarm and the function is reset. Causes for invalid internal data are, for example: • The frequency operating range of the device was left. • The device is not calibrated. • The A/D converter monitoring identified an error.

Routable Binary Input Signals (SPS Data Type)

Figure 3-36 shows the possible sources for connecting a binary input signal. Depending on the source, different quality attributes can be set.

- CFC chart: See description in chapter 3.3.3 Quality Processing/Affected by the User in CFC Charts
- GOOSE connection: See description in chapter 3.3.2 Quality Processing/Affected by the User for Received GOOSE Values
- Device hardware: No quality attributes are set and supported

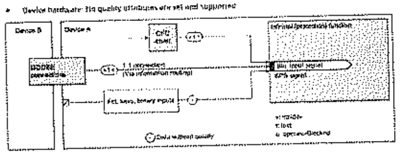

Figure 3-36 Sources for Connecting a Binary Input Signal

For this signal type (SPS), you can influence the processing of the quality, see overview in Figure 3-35. The following figure shows the possible influence on a binary input signal of a protection stage.

- In the DIGSI 5 project tree, double-click Information routing.
- In the operating range, select the desired binary input signal.
- In the Properties window, select the Details entry. There, you will find the item Processing quality attributes.

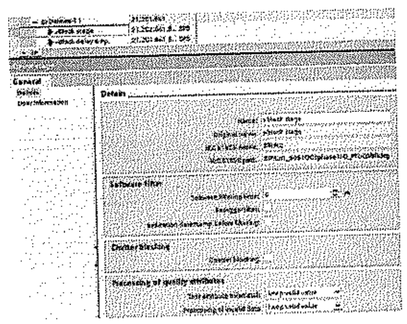

Figure 3-37 Influence Options for a Binary Input Signal (SPS Input Signal)

Quality Attribute: Validity	
The Validity attribute can have the values *good*, *invalid* (*reserved* and *questionable* were already replaced at the input end of the device by the value *invalid*).	
The input signal source is *invalid*.	The current data value of the source signal is ignored. You can select between the following options: • Further process last valid data value of the source signal (this is the default setting with only a few exceptions) • Set the binary value to be processed further to 0 • Set the binary value to be processed further to 1 This configuration option is necessary to satisfy different applications. The function health switches to Warning.
The input signal source is *good*.	The source signal data value is processed further.

Quality Attribute: Test	
• The input signal source and processed function are in test state. • The input signal source is not in test state and the function to be processed is in test state.	The source signal data value is processed further.

Quality Attribute: Test	
The input signal source is in test state and the function to be processed is in normal state.	The data value of the source signal is ignored. You can select between the following options: • Further processing of the last valid source signal data value, before the source switches to the test state (this is the default setting) • The binary value to be processed further is set to 0. • The binary value to be processed further is set to 1. This configuration option is necessary to satisfy different applications.

Quality Attribute: OperatorBlocked
The quality cannot be influenced at this position and does not lead to a response within the logic.

Output Data

The quality is not processed through the actual algorithm/logic of the function. The following table displays the conditions required to set the quality of output signals of a function.

Cause	DO Value	Quality Attribute	
		After internal (to the SIPROTEC 5 system, for example, in the direction of a CFC chart)	To the IEC 61850 interface, as buffer
Functional state = Test (thus, result of device operating mode = Test or function mode = Test)	Unchanged	Test = TRUE	Test = TRUE
Functional state = Off (thus, result of device operating mode = Off)	Function-specific, corresponding to the definition for 'switched off'	Validity = good	Validity = invalid
Function health = Alarm (for example, result of invalid receive data)	Function-specific, corresponding to the definition for reset	Validity = good	Validity = invalid
Device operating mode = functionally logged off	Unchanged	Validity = good OperatorBlocked = TRUE	Validity = good detailQual = oldData OperatorBlocked = TRUE

3.4 Fault Recording

3.4.1 Overview of Functions

All SIPROTEC 5 devices have a fault memory in which fault recordings are kept securely. Fault recordings document operations within the power system and the way in which protection devices respond to them. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA.

A fault record contains the following information:

- Sampled values of the analog input channels
- Measured values calculated internally
- Any binary signals (for example, pickup signals and trip signals of protection functions)

You can individually configure the signals to be recorded. Furthermore, you can define the starting condition, the record duration, and the saving criterion of a recording. Fault records saved in the device are also available after a loss of auxiliary voltage.

3.4.2 Structure of the Function

The Fault recorder function is a central device function. Both the recording criterion and the measured-value and binary channels to be recorded are functionally preconfigured through the application templates. You are able to individually adapt the configuration in DIGSI 5. The fault recording and the fault log are subject to the same control. This ensures that real time, relative time, and numbering of the fault data are synchronized. This means that all fault recordings function on the same real time and relative time basis.

The data read out via the DIGSI 5 are saved in COMTRADE format. Fault recording data can be transferred to the substation automation technology by request in accordance with the standards via existing communication connections (such as IEC 61850, IEC 60870-5-103). The central device analyzes the data using appropriate programs.

3.4.3 Function Description

The Fault recorder function records the sampled values, specific to each device, of all analog inputs, the internally calculated measured values and the binary signals. The configuration, which is predefined for each device via an application template, can be adapted individually.

> **NOTE**
>
> You can find detailed information about selecting and deleting fault records in the Operating Manual (C53000-G5000-C003).

The fault memory of the device is automatically updated with every recording. When the fault memory is filled completely, the oldest records are overwritten automatically. Thus, the most recent recordings are always stored safely. The maximum number of recordings is 128.

Sampling Frequency

The analog measuring channels are sampled at a different sampling rate for fault recording. The Sampling frequency parameter is used to set the desired sampling frequency. Possible setting values are 1 kHz, 2 kHz, 4 kHz, and 8 kHz. This setting value applies only to fault recording and does not affect protection functions or calculated measured values.

Record Duration

The overall duration of a single fault recording comprises the total duration of the configurable recording criterion, the Pre-trigger time and the Post-trigger time. You can set the parameters for these components individually.

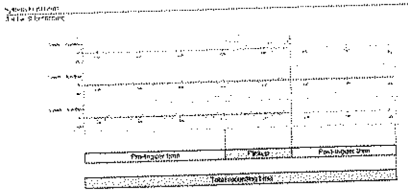

Figure 3-38 Example of a Fault Recording

With the Fault recording parameter, you specify the start criterion of the recording.

You can set the following values:

- with pickup
  The fault recording records the complete fault until dropout. The resulting pickup signals of all function groups are taken into account.
- user-defined
  With this setting value, you can individually specify the recording criterion for the fault recording in DIGSI 5. Function-specific recording criteria can be realized in this way.

If a recording criterion reoccurs during the pickup time and post-trigger time, the recording which is currently active is extended to include a new post-trigger time.

For a sampling frequency of 8 kHz and 24 analog channels to be recorded, the duration of one individual fault recording can be up to 20 s.

The maximum record duration can be limited by the Maximum record time parameter.

In addition to starting the fault recording via the pickup, the following alternatives are possible:

- Externally via binary input signal >External start (for example, from an external protection device without fault recording by an object transferred via a GOOSE message)
- By way of a configurable input signal >Manual start, you can start fault records with a configurable length (parameter Manual record time).
- With DIGSI 5, you can start test fault records with a fixed length of 1 s.
- With a command from a central device via an existing communication connection (IEC 61850, IEC 60870-5-103)

> **NOTE**
>
> If a pickup signal is present continuously, the fault recording is closed after the Maximum record time expires and the fault record cannot be restarted!

Saving the Recording

Not every fault recording that is started actually needs to be saved. With the Storage parameter, you specify whether or not you want to save the fault recording that has started. You can also save only fault data for which the pickup of a protection function also caused a tripping. With this setting, faults beyond the self-protection range will not lead to replacing fault recordings that have already been saved.

Configuration of Signals to Be Recorded

All analog inputs of the device that have been configured (currents and voltages) are recorded as sampled channels. Function-specific binary signals (for example, pickup and trip signals) and measured-value channels can be configured individually for recording in the DIGSI information-routing matrix. For this purpose, a separate Content column is available.

The operational measured values and the measured values of the fundamental components and symmetrical components (see the Device Manual, chapters 9.3 Operational Measured Values and 9.4 Fundamental and Symmetrical Components) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronous with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

Numbering and Time Stamping

All fault recordings saved are automatically numbered in ascending order and assigned a real-time stamp for the start time. The fault recording logs the fault with a relative time. The reference-time point is the start of the recording. Every fault record has a corresponding fault log with the same number. This ensures that the fault recording can be uniquely assigned to the event list.

Fault Memory

The device manages its available fault memory dynamically, so that the maximum recording capacity is always available. When exceeding the limits of the fault memory, the oldest recordings are automatically overwritten. This means that the most recent records are always available. The sampling rate, type, and number of measured value trends to be recorded are the crucial variables when it comes to restricting the length and number of records possible. Parallel to the sampled tracks, up to 50 tracks with function-specific measured values and up to 100 binary tracks can be recorded. The following table provides an overview of the maximum storage capacities, in seconds, for different connection variations of the protection devices.

Table 3-7 Maximum Length of all Stored Records

Connection Examples	Sampling 1 kHz	Sampling 2 kHz	Sampling 4 kHz	Sampling 8 kHz
Feeder: 4I, 6 measured values, 20 binary tracks	1365 s	819 s	455 s	241 s
Feeder: 4I, 4V, 20 binary tracks	1125 s	566 s	284 s	142 s
Feeder: 4I, 4V, 6 measured values, 20 binary tracks	820 s	550 s	266 s	137 s
Feeder 1.5 CB: 8I, 8V, 6 measured values, 20 binary tracks	525 s	281 s	145 s	74 s

Input and Output Signals

The Fault recorder function provides several input signals that allow the precise starting and deleting of records. The output signals provide information about the function status.

In the following table, you can find input signals of the Fault recorder function:

Name	Type	Description
Control: Start recording	SPC	Start recording via the function key
Control: Reset memory	SPC	Delete all recordings via the function key. The error numbers are reset.
Control: Delete memory	SPC	Delete all recordings via the function key. The error numbers remain as is.

Name	Type	Description
Control: >External start	SPS	Start recording by an external binary signal, for example, by the trip command of an external protection device without separate recording. The set pre and post-trigger time are taken into account.
Control: >Manual start	SPS	Start a recording of fixed duration (parameter Manual record time) by way of an external binary signal, for example, manually via the function key or by an external binary signal.

In the following table, you can find output signals of the Fault recorder function:

Name	Type	Description
General: Mode	ENC	Status feedback of the fault recording according to chapter 2.3 Function Control
General: State	ENS	
General: Standby	ENS	
Control: Error number	INS	The indication of the current error number allows a unique allocation of entries in the message buffer for the recorded fault records.
Control: Recording started	SPS	Fault recording running

3.4.4 Application and Setting Notes

Parameter: Fault recording

- Recommended setting value (_:2761:130) Fault recording = with pickup

With the Fault recording parameter, you define the time interval in which faults are recorded. The total record duration is defined as the duration of the fault plus the total of the parameters Pre-trigger time, Post-trigger time and is limited by the maximum record duration.

Parameter Value	Description
with pickup	The fault recording time is determined by the total number of all protection pickups. The resulting pickup signals of all function groups are taken into account. Note: When the post-trigger time has expired, the indications of an automatic reclosing function are not recorded. Tripping faults after expiry of the post-trigger time can result in the opening of a new fault with its own recording.
user-defined	The fault recording time is defined user-specific. Note: You must specify all signals for individual definition of the fault recording time in the DIGSI 5 information-routing matrix. In the information routing matrix in the Fault record column, the fault recording has for the purpose a separate column Trigger. The record duration is calculated from the logical OR operation of all initiated configured signals.

Parameter: Storage

- Recommended setting value (_:2761:131) Storage = always

With the Storage parameter, you define the storage criterion for a fault recording that has already started.

Parameter Value	Description
always	Each fault recording that has been started is saved.
with trip	If at least one protection function issues an operate indication during the record time, any fault recording that has been started will be saved.

Parameter: Maximum record time

- Default setting (_:2761:111) Maximum record time = 5.00 s

With the Maximum record time parameter, you configure the maximum record duration for an individual fault recording. When the time configured expires, an ongoing fault recording is canceled. This parameter merely limits the duration of the fault recording. It does not affect the logging of faults in the fault log.

Parameter: Pre-trigger time

- Recommended setting value (_:2761:112) Pre-trigger time = 0.50 s

With the Pre-trigger time parameter, you configure the pre-trigger time for an individual fault recording. The set pre-trigger time is prepended to the actual recording criterion for the fault recording.

Parameter: Post-trigger time

- Recommended setting value (_:2761:113) Post-trigger time = 0.50 s

With the Post-trigger time parameter, you configure the post-trigger time for an individual fault recording. The post-trigger time that has been configured is added to the actual recording criterion for the fault recording after the dropout.

Parameter: Sampling frequency

- Recommended setting value (_:2761:140) Sampling frequency = 8 kHz

With the Sampling frequency parameter, you define the sampling frequency of the fault recording. Possible setting values are 8 kHz, 4 kHz, 2 kHz, and 1 kHz.

Parameter: Manual record time

- Recommended setting value (_:2761:116) Manual record time = 0.50 s

With the parameter Manual record time, you set the duration of a recording if the fault record is activated dynamically (edge triggered) via a separately configured input signal >Manual start. In this case, pre-trigger and post-trigger times do not take effect.

3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2731:1	General:Mode		• on • test	on
Control				
_:2761:130	Control:Fault recording		• with pickup • with pickup & AR cyc. • user-defined	with pickup
_:2761:131	Control:Storage		• always • with trip	always
_:2761:111	Control:Maximum record time		0.20 s to 20.00 s	5.00 s
_:2761:112	Control:Pre-trigger time		0.05 s to 4.00 s	0.50 s
_:2761:113	Control:Post-trigger time		0.05 s to 0.50 s	0.50 s
_:2761:116	Control:Manual record time		0.20 s to 20.00 s	0.50 s
_:2761:140	Control:Sampling frequency		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	8 kHz

3.4.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2731:51	General:Mode (controllable)	ENC	C
_:2731:52	General:Behavior	ENS	O
_:2731:53	General:Health	ENS	O
Control			
_:2761:300	Control:Start record	SPC	C
_:2761:305	Control:Reset memory	SPC	C
_:2761:306	Control:Clear memory	SPC	C
_:2761:502	Control:>External start	SPS	I
_:2761:503	Control:>Manual start	SPS	I
_:2761:310	Control:Fault number	INS	O
_:2761:311	Control:Recording started	SPS	O
_:2761:314	Control:Record made	SPS	O
_:2761:327	Control:Error number	INS	O

ВЯРНО С ОРИГИНАЛА

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3.5 Protection Communication

3.5.1 Overview

Protection communication includes all functionalities required to exchange data via the protection interface (PI). It manages one or a maximum of 2 protection interfaces. The Protection communication is generated with the configuration of the channels as a protocol.

You can find detailed information in the section Protection interface in chapter 3.5.3.1 Overview of Functions.

3.5.2 Protection-Communication Structure

The following Protection communication functions are visible:

- Topology recognition
- Remote data

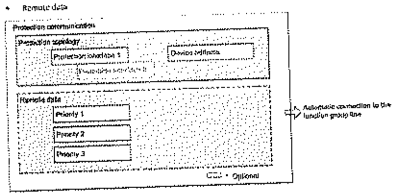

Figure 3-39 Protection-Data Communication Structure

Interface for Transformer/Auto Transformer Function Groups

Binary signals, measured values, and other data are automatically exchanged between Protection-data communication and the Transformer protection function groups or Auto transformers. In all cases the communication is optional.

Interface to Motor Function Group

Binary signals, measured values, and other data are automatically exchanged between the Protection-data communication and the Motor protection function group.

Remote Data

The Remote data functionality is applied if you route a specific signal or a measured value to the protection interfaces. The protection interface then attends to the transmitting and receiving of such signals. The maximum amount of remote data is defined by the available bandwidth.

3.5.3 Protection Interface and Protection Topology

3.5.3.1 Overview of Functions

The Protection topology and protection interface function enables data exchange between the devices via synchronous serial point to point connections from 64 kbit/s to 2 Mbit/s. These connections can be established directly via optical fibers or via other communication media, for example, via dedicated lines or via communication networks.

The following information that is significant for the function of the protection interface is also transferred. You cannot change this information:

- Topology data and values are exchanged for monitoring and testing the connection. The results are displayed on the device or with DIGSI 5.
- Protection data or teleprotection scheme binary data, are transferred for distance protection and ground-fault protection.
- The devices can be synchronized in time via the connection, whereby a device of the protection topology assumes the role of the timing master.

The connection is continuously monitored for data faults and outage, and the time delay of the data is measured.

The protection interfaces are typically used with the teleprotection scheme for distance protection and ground-fault protection. In SIPROTEC 5, you can configure protection interfaces in all devices and then use them for further protection applications. At the same time, any binary information and measured values can be transferred between the devices.

3.5.3.2 Structure of the Function

The protection interfaces of a device are located in the Protection communication function group. A device has 1 or 2 specifically parameterizable protection interfaces.

The protection topology is used for administration of the topology data relevant to the respective interfaces and containing data from other devices in the protection topology.

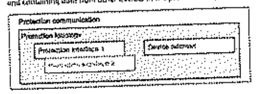

Figure 3-40 Structure of the Protection Interface in a Device

The protection communication runs physically via a serial optical communication module. This module can have 1 or 2 channels. The protection communication can take place via various modules. This depends on the type of interface and the application. DIGSI 5 is used to configure 1 or 2 channels of a serial optical module as a protection interface. This enables communication with the values set at the protection interface via this channel.

3.5.3.3 Function Description

Topology and Type of Protection Communication

The protection interfaces (PI) establish a direct point to point connection between devices via different communication media. Data can be transferred within the switchgear or between switchgears.

Devices connected to one another with protection communication form a protection topology.

2-Device Topology: Simple or Redundant Transfer

In the case of a simple 2-device topology, one protection communication per device is required (see next figure).

The most frequent application is the point to point exchange of data between 2 devices (the protection communication is of type 1), as performed by protection transmission devices. You can create a topology with up to 6 devices.

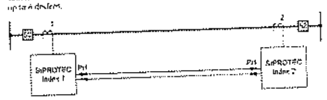

Figure 3-41 Data Exchange for 2 Devices, Each Having Protection Communication

> **NOTE**
>
> The index describes the consecutive numbering of the devices in a protection topology (see parameter `Local device is device`).

A maximum of 2 protection communications can be integrated in one device (see next figure). If 2 protection communications of the same type are connected to one another, this results in 100 % redundancy regarding the transmission route. The devices then search for the communication connection with the highest bandwidth (for example, optical fiber). If this connection fails, the system switches over automatically to the 2nd connection until the 1st connection is available again. As the connection with lower bandwidth defines the maximum amount of transferable information, the same information is exchanged via both connections. Both protection communications in the device are then of type 1.

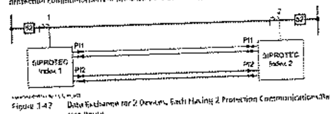

Figure 3-42 Data Exchange for 2 Devices, Each Having 2 Protection Communications/Redundant Transmission Route

Protection-Interface Information Transfer

With the protection-interface information transfer, customer-specific indications and measured values can be communicated via the protection interface with suitable update cycles (priorities).

There are 3 different priorities when transferring protection-interface information:

- Priority 1: Use Priority 1 for the transmission of fast protection signals that are transferred and updated at a maximum of every 20 ms in a telegram.
- Priority 2: Use Priority 2 for the transmission of fast single-point or double-point indications that are transferred and updated at a maximum of every 40 ms.
- Priority 3: Use Priority 3 for all indications, measured, and metered values that are transferred and updated a maximum of every 100 ms.

Communication Media

The communication takes place via direct fiber-optic connections, via communication networks or via 2-wire copper conductors. Siemens recommends a direct fiber optic connection, as this offers the highest transmission rate of 2 Mbps and is immune to failures in the communication route while offering the shortest transmission time. This also enables the transmission of a large amount of additional information on differential protection routes and the remote control of devices at the remote end with DIGSI 5.

The distance to be bridged and the transmission paths available determine the settings of the protection interface. External communication converters are used for the connection to communication networks via G703.1-, X21-, or G703.6 interfaces. The connection to 2-wire copper cores also takes place via a communication converter. The C37.94 interface, for example, with 2 Mbps, offers a direct fiber-optic connection to a multiplexer with the corresponding interface.

Table 3-8 to Table 3-9 show examples of communication connections.

In the case of a direct connection, the transmission distance depends on the fiber type of the optical fiber. This distance can also be extended via external repeaters.

The modules in the device can be replaced from outside, so that adaptation to a transmission route is possible. In the case of the 820-nm double module USART-AE-2FO with 2 channels, 2 protection interfaces can be operated on one module.

The modules can be located at slots E and F in the base device, and at slots N and P in the plug-in module assembly with integrated power supply.

When using communication converters, the connection from the device to the communication converter by a module is established via optical fibers.

Table 3-8 Plug-in Modules for Applications with the Protection Interface

Plug-in Modules	Module Type: USART-AF-1LDFO	Module Type: USART-AV-2LDFO	Module Type: USART-AG-1LDFO	Module Type: USART-AU-2LDFO	Module Type: USART-AK-1LDFO	Module Type: USART-AY-2LDFO	Module Type: USART-AH-1LDFO[1]	Module Type: USART-AJ-1LDFO[2]	Module Type: USART-AX-2LDFO[3]	Module Type: USART-AY-2LDFO[4]
Physical Connection										
1 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 μm singlemode optical fibers, 4 km via 62.5/125 μm multimode optical fibers	•									
2 x optical serial, 1300 nm, duplex LC plug, 24 km via 9/125 μm singlemode optical fibers, 4 km via 62.5/125 μm multimode optical fibers		•								
1 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 μm singlemode optical fibers			•							
2 x optical serial, 1300 nm, duplex LC plug, 60 km via 9/125 μm singlemode optical fibers				•						
1 x optical serial, 1550 nm, duplex LC plug, 100 km over 9/125 μm singlemode optical fibers					•					
2 x optical serial, 1550 nm, duplex LC plug, 100 km via 9/125 μm singlemode optical fibers						•				
1 x optical serial, bi-directional via 1 optical fiber, 1300/1550 nm (Tx/Rx), simplex plug LC, 40 km via 9/125 μm singlemode optical fiber							•			
1 x optical serial, bi-directional via 1 optical fiber, 1550/1300 nm (Tx/Rx), simplex plug LC, 40 km via 9/125 μm singlemode optical fiber								•		
2 x optical serial, bi-directional via 1 optical fiber, 1300/1550 nm (Tx/Rx), 2 x simplex LC plug, 40 km via 9/125 μm singlemode optical fiber									•	
2 x optical serial, bi-directional via 1 optical fiber, 1550/1300 nm (Tx/Rx), 2 x simplex LC plug, 40 km via 9/125 μm singlemode optical fiber										•

[1] USART-AH-1LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[2] USART-AJ-1LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side
[3] USART-AX-2LDFO only pairs with USART-AJ-1LDFO or USART-AY-2LDFO on the opposite side
[4] USART-AY-2LDFO only pairs with USART-AH-1LDFO or USART-AX-2LDFO on the opposite side

Table 3-9 Plug-in Modules USART-AD-1FO and USART-AE-2FO

Plug-in module	Plug-in Module USART-AD-1FO	USART-AE-2FO
Physical Connection		
1 x optical serial, 820 nm, ST connector, 1.5 km via 62.5/125 μm multimode optical fibers	•	
2 x optical serial, 820 nm, ST connector, 1.5 km via 62.5/125 μm multimode optical fibers		•
Application		
Protection interface (Sync. HDLC, IEEE C37.94)	X	X

> **NOTE**
>
> The USART plug-in module types can be used in slots E and F in the base module as well as in slots N and P in the CB202 expansion module. They are not suitable for use in port M in the CB202 expansion module.

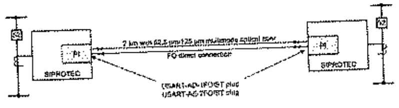

Figure 3-43 Connection over Short Distances, 1.5 km to 2 km via Multimode Optical Fiber

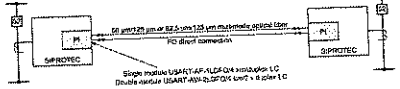

Figure 3-44 Connection over Maximum 4 km via Multimode Optical Fiber

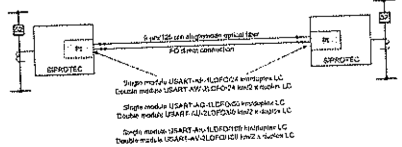

Figure 3-45 Connection via Different Distances via Singlemode Optical Fiber

> **NOTE**
>
> In order to prevent optical overload of the receiver, a 7XV5107-0AA00 attenuator must be used on one side in the fiber-optic modules USART-AF, USART-AG, USART-AH, USART-AK, and USART-AV for distances of less than 25 km/50 km.

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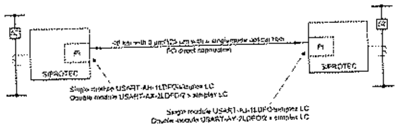

Figure 3-46 Connection via Singlemode Optical Fiber

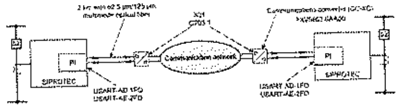

Figure 3-47 Connection via Communication Network with a G703.1 Interface

The connection to the multiplexer is established via a communication converter with a G703.1 interface (64 kbps) or X21 interface (64 kbps to 512 kbps). You can set the bit rate for the KU XG 512 (for X21), KU XG 256 (for X21), KU XG 128 (for X21), and KU XG 64 (for X21 or G703.1) with the parameter Connection via.

You can find more detailed information in Table 3-10.

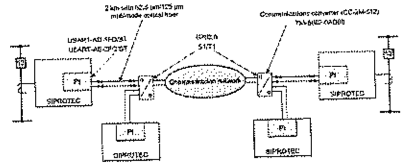

Figure 3-48 Connection via Communication Network with a G703.6 Interface

The connection to the multiplexer is established with 512 kbps via a communication converter with a G703.6 interface (E1 with 2 Mbps or T1 with 1.44 Mbps). The communication converter offers a 2nd interface for connecting an additional protection interface.

Make the setting for the bit rate with KU-2M 512 with 512 kbps in accordance with Table 3-10 with the parameter Connection via.

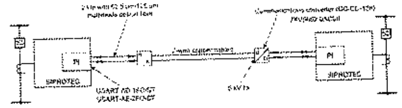

Figure 3-49 Connection via 2-Wire Copper Cables

The connection to a communication converter with an integrated 5-kV isolation voltage is established with 128 kbps (KU KU 128 setting) in accordance with Table 3-10. A 20 kV isolation of the 2-wire connection is possible via an external 7XR9516 isolating transformer.

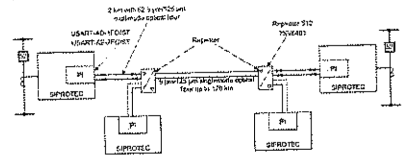

Figure 3-50 Direct Fiber-Optic Connection via an External Repeater

The repeater offers an interface for connecting an additional protection interface. The connection to a repeater is established with 512 kbps (repeater 512 setting) in accordance with Table 3-10.

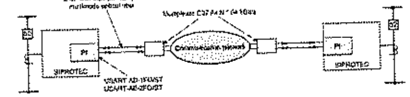

Figure 3-51 Direct Optical Connection to a Multiplexer with a C37.94 N * 64 kbps Interface (Time Slot N = 1, 2 or 8)

> **NOTE**
>
> The redundancy of different communication connections (for the ring topology) requires rigorous separation of all devices involved in the communication. Therefore, avoid different communication routes via the same multiplexer board, as no more substitute paths are possible if the board fails.

Supervision of the Communication

The communication is continuously monitored by the devices.

If a number of defective data telegrams, or no data telegrams at all, are received, this is regarded as a failure in the communication as soon as a failure time of 100 ms (default setting can be changed) is exceeded. A list of the measured values is shown in a window in DIGSI 5 (defective telegrams per minute/hour, transmitted and received telegrams per minute/hour, percentage fault rate per minute/hour). A corresponding indication is always available. If no alternative communication route exists (as in the ring topology), the protection function operating with the protection interface is not operating and the remote signals are not updated on the receiver side.

If the communication is interrupted for longer than an adjustable time **Data-connection failure**, this is regarded as a communication failure. A corresponding failure indication is always available.

Time Synchronization via the Protection Interface

All devices of a topology can be time-synchronized with one another. Synchronization is carried out with millisecond accuracy. The synchronization works independently of the protection function and is exclusively for simultaneous time keeping in the devices of a protection topology.

The device you set in the parameter Address of device 1 is the device with index 1. This device functions as the timing master in a protection topology. If the timing master is turned off and switched off, the device with the next highest device index takes on the function of the timing master. The timing master synchronizes the clocks of the other devices of this topology via the protection interfaces. The time of the timing master is typically synchronized via a substation automation protocol (for example, Ethernet or SNTP) or via IRIG-B. For this, these time sources must be set as the 1st time source and optionally as the 2nd time source in the timing master. If available, the system switches over to the 2nd source upon outage of the 1st source in the timing master. This time is communicated with millisecond accuracy to the other devices of the topology.

Set the protection interface as the 1st time source in the other devices of the topology. In this way, all events in the devices of the protection topology are recorded with the same time and are time-synchronized even across different substations. This simplifies fault analysis and the fault records are recorded with the same time in all devices.

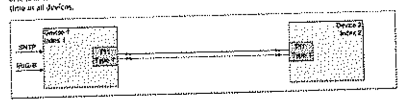

Figure 3-52 Time Synchronization in a Protection Topology

Figure 3-52 shows how device 1 with index 1 is synchronized with device 2 via the protection interface. Device 1 is synchronized externally from 2 sources (IRIG-B and SNTP via Ethernet).

Time Synchronization of the Line Differential Protection Measured Values with Millisecond Accuracy

The measured values of the line differential protection for the various line ends are synchronized with each other with microsecond accuracy via the mechanisms of the protection interface. The protection interface displays this state with the RAISING indication *Protection interface synchronized*.

If communications problems occur, it is possible that the measured values may not be properly synchronized. In this case, the protection interface generates the CLEARED indication *Protection interface synchronized*. The line differential protection is blocked. This state can be corrected only by manual intervention.

> **NOTE**
>
> You can reset the synchronization of the protection interface directly in the device. Proceed as follows: **Device functions > x Device protection comm. > Protection interface y > Reset synchron.**

Log Off the Device

A device can be logged off for protection-function tests, system inspections, or disconnection of a feeder for operational reasons. The device that is logged off no longer participates in the distributed functionality and is therefore no longer a component of the topology. The protection functions are still in operation for the other end or ends.

The following conditions are necessary for a successful logoff of the device from the point of view of protection communication:

- The protection topology is not in a transient state and is stable in operation without mischievous.
- The local device is one of the 2 token masters if there is a chain topology. The token masters are the devices at the ends of the chain.
- The circuit breaker must be open and current must not be flowing.

> **NOTE**
>
> If one of these conditions is not fulfilled, the device cannot be logged off.

3.5.3.4 Initialization and Configuration of the Protection Interface in DIGSI 5

If the device is provided with modules, proceed as follows:

- Select the desired communication module in the rear view of the device.
- Use the Communication protocols text box to select the protection interface. A text box entitled Protection interface will then appear.

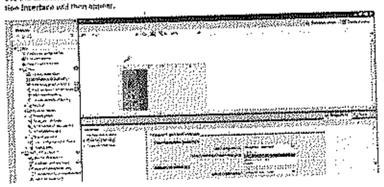

Figure 3-53 Selection of the Communication Protocol

- Then select the Select constellation text box to select the number of devices (see next figure). Depending on the device, the selection of constellations can be restricted to 2 or 3 devices. The number of devices is an order option with regard to differential protection.

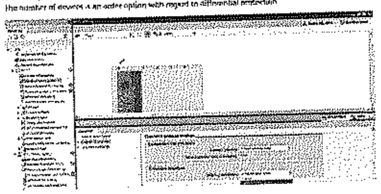

Figure 3-54 Selecting the Constellation

> **NOTE**
>
> You have the option of changing the number of devices (for example **2 protection communication devices**) depending on the product code any way you like via the **Select constellation** text box.
>
> If you change the number of devices via the **Select constellation** text box, all activated constellation settings are lost.

If the module slot is not yet provided with modules, proceed as follows:

- Select the desired communication module in the rear view of the device.
- Select the module from the catalog and drag it to a channel. That is the channel configured with a module. DIGSI 5 indicates whether the module can be used for protection communication under Device information.
- Use the Communication protocols text box to select the protection interface. A text box entitled Protection interface will then appear (see Figure 3-53).
- Then use the Select constellation text box to select the number of devices (for example **2 devices protection comm.**) (see Figure 3-54).

3.5.3.5 Device-Combination Settings

Make the device combination settings and the settings for protection communication (see next figure).

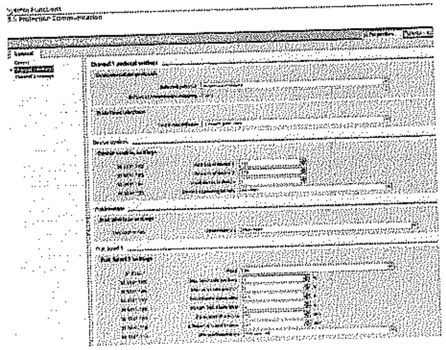

Figure 3-55 Protection Interface Initialization and Configuration

Changes in a channel are always visible on the other channel as well. All further parameters can be set separately for individual channels.

Setting Device-Combination Settings

- Default setting (_:5131:102) Address of device 1 = 101
- Default setting (_:5131:103) Address of device 2 = 102

The parameters Address of device 1 to Address of device 3 can be used to give an address to each device. Set a unique and unambiguous address for each device.

- Default setting (_:5131:101) Local device is device = 1

With the Local device is device parameter, you set the index (number) of your device in the topology. A maximum of [illegible] devices can be present in one topology.

APPLICATION EXAMPLE

You have a topology with 2 devices.

For example, in DIGSI 5, select the parameter setting Address of device 1 with the parameter value 101 for device 1 and the parameter setting Address of device 2 with the parameter value 102 for device 2.

Then, use the Local device is device parameter to set the index of the local device.

620

The addresses must be configured identically for all devices involved in the constellation. A functional protection communication requires that you also assign the same index in all devices of a constellation for a device with a unique address.

- Default setting (_:5131:122) Lowest appearing bit rate = 64 kbit/s

The Lowest appearing bit rate parameter is used to set the smallest occurring bit rate in the device group. Set the smallest value in each device with a three-end constellation with 2 fiber-optic connections (2 MBit/s) and a 64 kBit/s connection with the lowest value (64 kBit/s). This value determines the maximum signals and measured values within a constellation.

Apart from the default value, you can also set the following bit rates:

- 128 kbit/s
- 512 kbit/s
- 2048 kbit/s

NOTE

If you use fiber optic cables for the connection between the devices, set the value to 2048 kbit/s.

3.5.3.6 Selecting the Connection

- Default setting (_:105) Connection via = fiber optic

The Connection via parameter is used to set the bit rate required for the protection interface. Different discrete values can be entered depending on the means of communication (see following table).

Table 3-10 Means of Communication

Means of Communication	See	Setting Value	Bit Rate
Fiber-optic direct connection	Figure 3-4 to Figure 3-4	fiber optic	2 MBit/s
CC-XG-512 communication converter	Figure 3-4	CCXG 512 kbit/s	512 kBit/s
CC-XG-128 communication converter	Figure 3-4	CCXG 128 kbit/s	128 kBit/s
CC-XG 64 communication converter	Figure 3-4	CCXG 64 kbit/s	64 kBit/s
Repeater 512 communication converter	Figure 3-4	Repeater 512 kbit/s	512 kBit/s
CC-CC 128 Communication converter	Figure 3-4	CCCC 128 kbit/s	128 kBit/s
CC-2M-512 Communication converter	Figure 3-4	CC2M 512 kbit/s	512 kBit/s
Multiplexer with C37.94 interface	Figure 3-4	C37.94 1 * 64 kbit/s C37.94 2 * 64 kbit/s C37.94 8 * 64 kbit/s	64 kBit/s 128 kBit/s 512 kBit/s
Other (freely adjustable bit rates for a direct connection for special applications)		64 kbit/s 128 kbit/s 512 kbit/s 2048 kbit/s	64 kBit/s 128 kBit/s 512 kBit/s 2048 kBit/s

3.5.3.7 Setting Notes for the Protection Interface

Parameter: Max. Error Rate/h

- Default setting (_:5161:105) Max. error rate per hour = 1.0 %

The Max. error rate per hour parameter allows you to receive an error message on the number of faults per hour. An indication is then generated.

Parameter: Max. Error Rate/min

- Default setting (_:5161:106) Max. error rate per min = 1.0 %

The Max. error rate per min parameter allows you to receive an error message on the number of faults per minute. An indication is then generated.

Parameter: Disturbance Alarm After

- Default setting (_:5161:107) Disturbance alarm after = 100 ms

The Disturbance alarm after parameter determines the time delay after which defective or missing telegrams are signaled as faulty.

Parameter: Transm. Fail. Alarm After

- Default setting (_:5161:108) Transm. fail. alarm after = 6.0 s

The Transm. fail. alarm after parameter is used to set the time after which a failure of the communication is signaled.

NOTE

If the setting values of the parameters Disturbance alarm after and Transm. fail. alarm after are exceeded, then an indication is generated.

Parameter: Delay time threshold

- Default setting (_:5161:109) Delay time threshold = 30.0 ms

For the Delay time threshold, the default setting is selected such that it is not exceeded by normal communication networks. If this time delay is exceeded during operation (for example, upon switchover to another transmission route), the indication Time delay exceeded is issued.

Parameter: Difference Tx and Rx time

- Default setting (_:5161:110) Difference Tx and Rx time = 0.1 ms

The Difference Tx and Rx time parameter can be used to set a maximum time-delay difference between the send and receive paths.

Set this value to 0 for a direct fiber-optic connection. A higher value is necessary for transmission via communication networks. Reference value: 0.1 ms (recommended setting value).

NOTE

Only if the line differential protection function is instantiated, the Difference Tx and Rx time parameter is displayed.

NOTE

If the user employs a multiplexer with a C37.94 interface as a communication medium, Siemens recommends a setting value of 0.25 ms to 0.6 ms.

Parameter: PPS Synchronization

- Default setting (_:5161:113) PPS synchronization = PPS sync. off

If the SIPROTEC device operates with PPS synchronization (PPS: pulse per second), use the PPS synchronization parameter to define how the protection is activated after restoration of the communication connection (basic state or after transmission fault).

Refer to Figure 3-56.

NOTE

The PPS measurement is used to consider the time delay in the send and receive directions. If PPS fails due to a reception fault or due to a short-term unfavorable satellite position, synchronization via conventional communication media remains active.

The PPS synchronization parameter offers 3 different setting options:

Parameter Value	Description
telegr. and PPS	With this setting, the differential protection is only enabled upon renewed establishment of the connection, if the communication section is synchronized via PPS or if symmetrical time delays are signaled by an external operation (binary input). This results in synchronization with the telegram measurement supported by the PPS measurement.
telegr. or PPS	In this setting, the differential protection is enabled immediately upon renewed establishment of connection (data telegrams are received). The conventional method is used up to synchronization. This results in synchronization with the telegram measurement supported by the PPS measurement.
PPS sync. off	This setting means that no synchronization is performed via PPS at the protection interface. This is typically the case if no time-delay differences are expected. The synchronization only takes place with the telegram measurement.

NOTE

The synchronization mode can be set separately for both protection interfaces.

If no further PPS pulse is received within 2.1 s, the time out supervision responds. If no new 2nd pulse occurs after the expiry of the supervision time, the indication PPS pulse loss is issued.

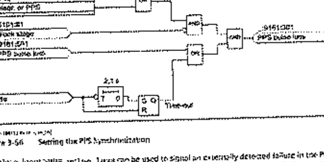

Figure 3-56 Setting the PPS Synchronization

The binary input >PPS pulse loss can be used to signal an externally detected failure in the PPS signal (for example, error message from the receiver). Setting this binary input also leads to the indication PPS pulse loss.

If you are using a second pulse from a GPS receiver, you must ensure that a loss of reception or reception disturbances do not generate a second pulse. The GPS receivers recommended by Siemens are set by default so that a loss of reception or reception disturbances do not generate a second pulse. In the event of problems, check the setting value for the second pulse.

Siemens recommends the Meinberg 164 GPS receiver. Check the default setting for the second pulse using the GPSMON32 program. The program is available in the SIPROTEC download area. You can find the setting value under Outputs → Enable Flags. The second pulse must be set to the value if Sync.

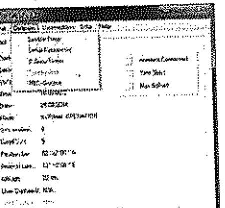

Figure 3-57 Checking the Setting Value for the 2nd Pulse Using the GPSMON32 Program, Step 1

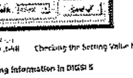

Figure 3-58 Checking the Setting Value for the 2nd Pulse Using the GPSMON32 Program, Step 2

3.5.3.8 Routing Information in DIGSI 5

Protection communications of the same type form a topology.

For more information on this, see chapter 3.5.3.3 Function Description.

A data bar is exchanged between the devices of a topology connected via protection communication. This can be written into or read from by the devices. This can be used for exchanging various signals between the devices. In this case, each signal demands a certain number of data fields.

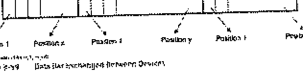

Figure 3-59 Data Bar Exchanged Between Devices

The data bar is divided into 3 priorities, which also have different transmission rates and data volumes.

The following basic principle applies for all messages: Only pure data contents are transmitted. The quality (for example, Test flag) is not automatically transmitted as well. If you want to transmit the quality as well (for example, for further processing of GOOSE messages), the quality must be transmitted separately (for example, by using CFC). If a signal that has a test flag is transmitted (because the function is in test mode, for example), all signals are provided with a test flag on the receiving side. If the connection is broken, all received signals are flagged with the quality Invalid. If desired, the value can also be set to a secure state after a selectable dropout time, or the last value received can be retained (Hold setting). This can be configured separately for each received signal (see Table 3-14).

NOTE

For ACT type signals, only the phase information is transmitted.

Indications that are transferred data fields of priority 1 are sent with every telegram. They are preferably used for the transmission of rapid signals, for example, release for circuit-breaker intertripping. A steady deterministic, rapid transmission is required there.

Signals of priority 2 are transmitted with at least every 2nd telegram. For bit rates ≥ 256 kBit/s, there are no differences between priority 1 and priority 2.

Priority 3 information is transmitted at least every 100 ms. This priority is used for transmission of measured and metered values. Complex values must be routed separately as the real and the imaginary part for transmission. Measured-value thresholds that lead to an updating of a measured value are set centrally at a property of the measured value. These measured-value thresholds apply with the corresponding reporting, for example, also for the transfer via IEC 61850 to a substation automation technology.

Indications which are written to a data area under a priority on the data bar must be routed to an indication of the same type in the device reading this information. Otherwise, they are processed incorrectly on the receiving side. The data bar is organized in terms of bits. For information on the bit requirement of each signal type, refer to Table 3-13.

Table 3-11 and Table 3-12 show the number of data areas in the data bar in relation to the available baud rate.

NOTE

The Lowest appearing bit rate parameter, which has to be set in each device for the protection interfaces of a topology, defines the number of data areas as well as the topology type.

If, for example, in a three-end constellation with a type 2 chain topology, two devices are connected via direct optical fibers and 2 devices via the 64 kBit/s weakest line, the 64-kBit/s section is the limiting factor for the entire constellation.

Table 3-11 Available Bits - Minimum Constellation Baud Rate 64/128 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	8 Bits	24 Bits	128 Bits
Type 2	32 Bits	64 Bits	256 Bits

Table 3-12 Available Bits - Minimum Constellation Baud Rate 512/2048 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	48 Bits	128 Bits	384 Bits
Type 2	96 Bits	200 Bits	1024 Bits

Table 3-13 Requirement in Bits

Signal Type	Size in Bits
SP (single-point indication)	1 Bit
DP (double-point indication)	2 Bits
IN (metered values)	32 Bits
MW (measured values)[1]	32 Bits
ACT	4 Bits

Table 3-14 Possible Dropout Values

Signal Type	Dropout Values
SP (single-point indication)	Outgoing, Incoming, Hold
DP (double-point indication)	On, Off, Intermediate Position, Disturbed Position, Hold
IN (metered values)	0, Hold
MW (measured values)	0, Hold
ACT	Hold

NOTE

If the protection link fails, these values can be set on the receiver side.

EXAMPLE

2 devices are connected with differential protection via a 64-kBit/s channel. This is a type 1 topology. 8 bits are freely available for priority 1. Thus, for example, 4 SPS and 2 DPS can be routed:

4 x 1 Bit + 2 x 2 Bits = 8 Bits

[1] The complex values of a measured point are processed

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NOTE

Measured values are transmitted as primary values.

Remote Data Transmission: Routing of the Indications and Measured Values to the Protection Interface

The transmission is organized in the form of a data bar which is continuously exchanged between the devices. For this, see Figure 3-59.

A device indication or measured value is allocated to a definite data area of the bar.

Figure 3-60 to Figure 3-63 show the routing for a communication topology of protection interface type 1.

To transmit signals to other devices, these signals must be routed in the communication matrix under Transmit. Binary inputs 1 and 2 are single-point indications (SPS) and are routed to position 1 and position 2 of the transmission with the highest priority (priority 1). For 64 kBit/s, for example, only 8 of these data areas are available for type 1; they are exchanged between the transmission routes with each telegram. Signals 3 and 4 are double-point indications (DPS), for example, a switch position that is transmitted by a device 1. A double-point indication occupies 2 positions on the data bar. In addition, a measured and metered value are communicated via priority 3.

As a measured or metered value uses 32 bits, value 2 starts at position 33. DIGSI 5 indicates the next available position.

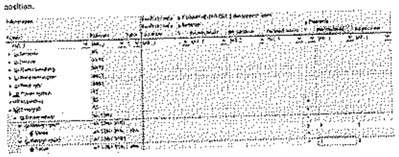

Figure 3-60 Routing of Single-Point Indications to the Protection Interface in Device 1

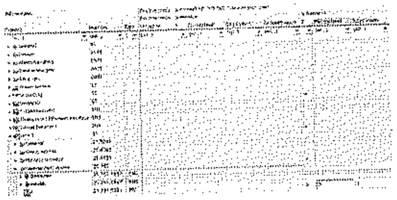

Figure 3-61 Routing of Measured Values to the Protection Interface in Device 1

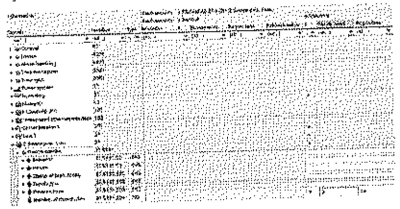

Figure 3-62 Routing of Metered Values to the Protection Interface in Device 1

This device also receives information (in the matrix under Receive). This must have been routed as a target for other devices (see next figure). The binary outputs 1 and 2 in device 1 receive their information via the protection interface. This is priority 1 information, which has been routed in another device to positions 3 and 4 of the data bar. The secure state is defined in the Fallback value column. If the data connection fails, the single-point indication is reset to coming or going or its value is retained (hold). For data of the various priorities, you can also set a dropout time after which the resetting (see Figure 3-62) to the fallback value occurs, in order to retain the original state for a short time in the event of brief interruptions. These 3 dropout times apply for all data of one transmission priority and are set as parameters.

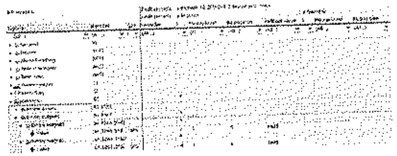

Figure 3-63 Routing of Single-Point Indications (Receive) to the Protection Interface in Device 1

The following figure shows the routing in the 2nd device. Binary inputs 1 and 2 are routed with priority 1 to positions 3 and 4 there. In device 1, positions 1 and 2 are already occupied (see Figure 3-60). If you also route the signals to positions 1 and 2, the signals of the devices are then connected to the corresponding position with a logical OR operation. If measured and metered values are routed in the same data areas, this results in implausible values for the receivers that read the data. As a user, you are therefore responsible for the correct routing.

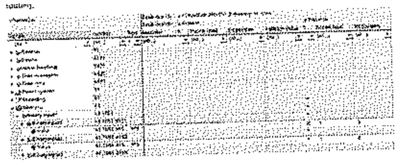

Figure 3-64 Routing of Single-Point Indications to Be Sent to the Protection Interface in Device 2

The binary outputs 1 and 2 (Receive) in the 2nd device are connected to priority 1 signals 1 and 2 from the 1st device. This takes place via the data areas at positions 1 and 2 of the data bar, which transfer the state of the indications. Other devices can also read this information and link it to their internal signals. Here, too, the secure state, which is assumed when the protection connection is interrupted, is entered. This state depends on the information. In the case of single-point indications, the state is 0 or 1. In the case of double-point indications, the bit combinations 00, 01, 10, or 11 are possible, in order to directly signal a disturbed position upon failure of the data connection, for example.

Hold is used to retain the state.

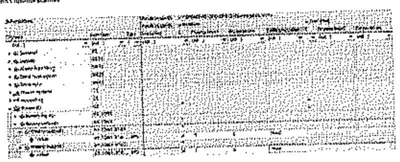

Figure 3-65 Routing of Received Single-Point Indications to the Protection Interface in Device 2

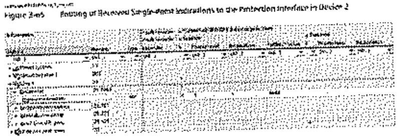

Figure 3-66 Routing of Received Measured Values to the Protection Interface in Device 2

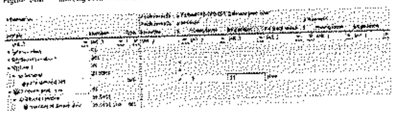

Figure 3-67 Routing of Metered Values to the Protection Interface in Device 2

3.5.3.9 Diagnostic Measured Values of the Protection Interface

Constellation measured values are measured values that have been predefined by Siemens and which are time-synchronized in the devices, exchanged across the protection interfaces and made available in any device.

NOTE

No constellation measured values are available in the 7UT8x devices.

The following diagnostic data is provided via the protection interface by the devices in the constellation:

- Address of the device in the constellation
- Circuit-breaker switch position (open/closed/undefined)

- Availability of protection-interface communication within the last minute, as percentage
  Availability of protection-interface communication within the last hour, as percentage
- Time delay in the send and receive direction of the telegrams between local and neighboring device

You can find the diagnostic data in DIGSI under the following menu structure (see Figure 3-68 and Figure 3-69):

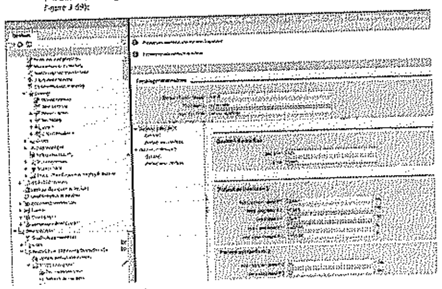

Figure 3-68 Protection-Interface Channel Diagnostic Data – Device Address

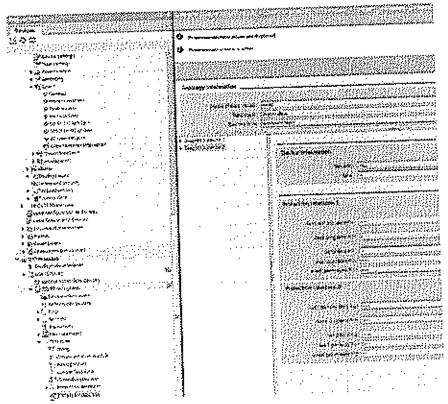

Figure 3-69 Diagnostic Data of the Protection-Interface Channels – Device 2 Not Connected

NOTE

You can use the following procedure to reset the measured values for the protection interface directly in the device:

Device functions > x Device protection comm. > Protection interface y > Reset measured values

Output Signals of the Protection Interface

Each individual protection interface provides the following indications for commissioning and diagnosing communications:

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Indication	Description
(_:5161:301) Status of lay. 1 and 2	The output signal gives you information about the state of communication layers 1 and 2 (1: Physical Layer, 2: Data Link Layer). The following indications values are possible: • Initialized The protection interface is not connected and is in the initial state. • Protection interface connected The protection interface is connected to the protection interface of a device. • Protection interface disturbance The protection interface has not received any valid telegrams for the time set in parameter (_:5161:107) Disturbance alarm after. • Protection interface failure The protection interface has not received any valid telegrams for the time set in parameter (_:5161:108) Transm. fail. alarm after. • not present The protection interface has not been assigned to a communication channel.
(_:5161:302) Status of lay. 3 and 4	The output signal gives you information about the state of communication layers 3 and 4 (3: Network Layer, 4: Transport Layer). The following indications values are possible: • no error The protection interface is operating correctly. • Software version incompatible The firmware versions of the connected devices are incompatible. Update the firmware. • System mirroring The protection interface is receiving its own data. Check the wiring. • Dev. add. incorrect The device address of the partner device is incorrect. Check the settings for parameters Address of device 1 to Address of device n (_:5131:102 and following). • Constell. incorrect The constellation settings of the devices are different. Check that the setting for the parameter Select constellation is identical in all devices. • Const. param. incorrect Check that the same setting has been made for parameter (_:5131:122) Lowest appearing bit rate in all devices. • Diff. Param. Error The line differential protection settings for the connected devices are incompatible. Check whether both devices are set to operate with or without line differential protection. The rated value of the line (parameter (_:9001:101) Rated current and (_:9001:102) Rated voltage) must have the identical setting at both ends of the line. If a transformer is installed in the line, both parameters must be set such that the rated apparent power is the same at both ends of the line (parameter (_:9001:103) Rated apparent power).

In order to clarify faults, each individual protection interface provides the following binary signals.

Binary Output Signal	Description
(_:5161:303) Connection broken	Signal Connection broken indicates that during a parameterized time (parameter (_:5161:107) Disturbance alarm after) faulty or missing telegrams were continuously received. If the Connection interrupted indication occurs, the affected protection interface link will be terminated. This can cause the blocking of an active differential protection or a ring topology can change to a chain topology.
(_:5161:316) Error rate / min exc.	Signal Error rate / min exc. indicates that the set maximum error rate per minute (Parameter (_:5161:104) Max. error rate per min) has been exceeded.
(_:5161:317) Error rate / hour exc.	Signal Error rate / hour exc. indicates that the set maximum error rate per hour (Parameter (_:5161:105) Max. error rate per hour) has been exceeded.
(_:5161:318) Time delay exceeded	Signal Time delay exceeded indicates that the threshold value for the set signal-transit time (Parameter (_:5161:109) Delay time threshold) has been exceeded.
(_:5161:319) Time delay different	Signal Time delay different indicates that the threshold value for asymmetrical transit times has been exceeded. The setting value results from the setting value of the parameter (_:5161:110) Difference Tx and Rx time.
(_:5161:320) Time delay jump	Signal Time delay jump indicates that the data transit times changed abruptly. This is caused by switching the communication path in the communication network.
(_:5161:321) PI synchronized	Signal PI synchronized indicates that the protection-interface connection is synchronized with the opposite end.
(_:5161:340) Telegram lost	Signal Telegram lost indicates that an expected telegram has failed to arrive or a faulty telegram has been received. If you would like to allocate the communication failures or faults to other events, move the signal Telegram lost temporarily into the operational log. Such events can be switching operations in the primary system or operations on the components of the communication network. Note: If the signal is constantly routed, the operational log can overflow. Siemens recommends routing the signal only for clarification of faults.

Measured Values of the Protection Interface

The protection interface provides the following measured value to diagnose the protection interface communication:

Measured Value	Description
(_:5161:308) Tx tel/h	Telegrams sent during the last hour
(_:5161:309) Rx tel/h	Telegrams received during the last hour
(_:5161:310) Tx tel/min	Telegrams sent during the last minute
(_:5161:311) Rx tel/min	Telegrams received during the last minute
(_:5161:312) Tx err/h	Transmission failure rate during the last hour
(_:5161:313) Rx err/h	Reception failure rate during the last hour
(_:5161:314) Tx err/min	Transmission failure rate during the last minute
(_:5161:315) Rx err/min	Reception failure rate during the last minute

Measured Value	Description
(_:5161:325) Average Δt	Mean signal-transit time (average value of the transit time in transmission and reception direction divided by 2, without GPS synchronization)
(_:5161:326) Rec. Δt	Signal-transit time in reception direction (with GPS synchronization)
(_:5161:327) Sen. Δt	Signal-transit time in transmission direction (with GPS synchronization)
(_:5161:334) Miss.tel/min	Number of telegram failures within the last minute
(_:5161:335) Miss.tel/h	Number of telegram failures within the last hour
(_:5161:336) Miss.tel/d	Number of telegram failures within the last day
(_:5161:337) Miss.tel/w	Number of telegram failures within the last week
(_:5161:338) M.loss/d	Longest lasting telegram failure within the last day
(_:5161:339) M.loss/w	Longest lasting telegram failure within the last week

NOTE

You can reset the measured values of the protection interface directly at the device. Proceed as follows: **Device functions > x Device protection comm. > Protection interface y > Reset measured values.**

3.5.3.14 Diagnostic Data for the Protection Interface

Diagnostic Data of the Channel in DIGSI 5

Different diagnostic data can be read with DIGSI 5.

For this, connect with the device via DIGSI 5 and query the device information. Diagnostic data for a module whose channel is configured with the protection interface can be received by selecting the module slot (for example, F) and the corresponding channel (1 or 2). The following figures show the extensive diagnostic data for the protection interface. It is particularly helpful if data failures occur or other irregularities in a communication connection (for example, transmission time fluctuations).

NOTE

The diagnostic data can also be read via the device control on the display of the device. The overview of DIGSI 5 does not offer this option, however.

The following table describes the displays.

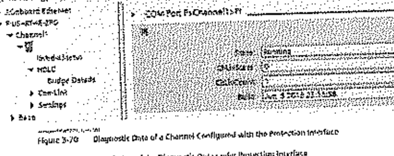

Figure 3-70 Diagnostic Data of a Channel Configured with the Protection Interface

Table 3-15 Description of the Diagnostic Data under Protection Interface

Channel Type	Name	Values	Description - Diagnostic Information for Log PI
Protection interfaces - log	Status	Initial, Running, Error	Runtime status of the log
Protection interfaces - log	Build	Date/time	Date and time of the log version

Diagnostic Data of the Protection-Interface Log in DIGSI 5

The following figures and tables describe the displays of the protection-interface log.

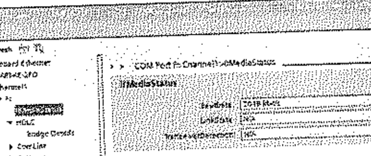

Figure 3-71 Diagnostic Data of the Protection Interface Log - Media Status

Table 3-16 Description of Diagnostic Data under Media Status

Protection Interfaces - Log Type	Name	Values	Description - Media Status Interface (in Direction of Outside Interface)
Media Status	Baud rate	64 kBit/s; 128 kBit/s; 512 kBit/s; 2048 kBit/s; 30 MBit/s; unknown	HDLC baud rate: FO: 64 kBit/s to 2048 kBit/s for 820-nm USART modules LDFO: 30 MBit/s for 1300/1500-nm long-distance modules Error case: unknown
Media Status	LinkState	N/A, UP, DOWN	FO: N/A (always display N/A)
Media Status	TransceiverDetection	N/A, NO Transceiver detected, Transceiver detected	FO: N/A (always N/A) (NO Transceiver detected, Transceiver detected), Error case: N/A

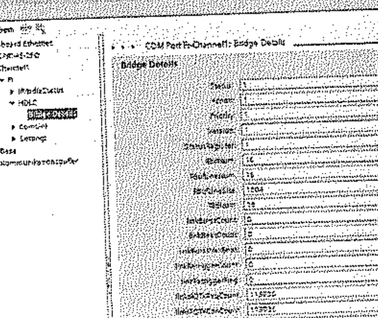

Figure 3-72 Diagnostic Data of the Protection Interface Log - HDLC (Log - Layer)

Table 3-17 Description of Diagnostic Data of the Protection-Interface Log - HDLC (Log - Layer)

Protection Interfaces - Log Type	Name	Values	Description - HDLC Link Layer Diagnostic Information (in Direction of Outside Interface)
HDLC	RXHPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, OK
HDLC	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, OK
HDLC	RXHPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, faulty
HDLC	RXLPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, faulty
HDLC	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, OK
HDLC	TXLPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, OK
HDLC	TXHPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, faulty
HDLC	TXLPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, faulty
HDLC	Bridge Details Sub-nodes	Sub-nodes	Siemens-internal specific diagnostic for tech support

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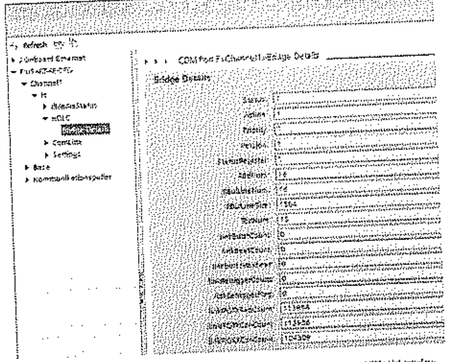

Figure 3-73 Diagnostic Data of the Protection Interface Log – COM Interface (Internal COM Link Interface between Module and Mainboard)

Table 3-19 Description of Diagnostic Data of the COM Interface (Internal COM Link Interface Between Module and Mainboard)

Protection Interfaces - Log Type	Name	Values	Description - COM Interface Layer Diagnostic Information (Internal COM Link Interface in Mainboard Direction)
COM interface	RXHPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, OK
COM interface	RXLPFramesOK	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, OK
COM interface	RXHPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, high priority, faulty
COM interface	RXLPFramesERR	Number of corresponding frames (16 bit counter)	Incoming telegrams, low priority, faulty

Protection Interfaces - Log Type	Name	Values	Description - COM Interface Layer Diagnostic Information (External COM Link Interface in Mainboard Direction)
COM interface	TXHPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, OK
COM interface	TXLPFramesOK	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, OK
COM interface	TXHPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, high priority, faulty
COM interface	TXLPFramesERR	Number of corresponding frames (16 bit counter)	Sending telegrams, low priority, faulty
COM interface	Bridge Details Sub nodes	Sub nodes	Siemens internal special diagnostic for fault search

Table 3-19 Description of Diagnostic Data of Some Setting Values of the Protection Interface

Protection Interfaces - Log Type	Name	Values	Description - Protection Interface Setting Values
Settings	Connection via	Integer number - display of the internal coding of the settings values	Protection interface is Connection via
Settings	PDI bandwidth	Bit rate display	Bit rate (kbit/s) for protection telegrams based on the parameter Connection via
Settings	PDI Telegram Overhead	Display of bits	Overhead for every protection telegram in bit.

3.5.3.11 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device combin.				
_:5131:102	Device combin.:Address of device 1		1 to 65534	101
_:5131:103	Device combin.:Address of device 2		1 to 65534	102
_:5131:104	Device combin.:Address of device 3		1 to 65534	103
_:5131:105	Device combin.:Address of device 4		1 to 65534	104
_:5131:106	Device combin.:Address of device 5		1 to 65534	105
_:5131:107	Device combin.:Address of device 6		1 to 65534	106
_:5131:101	Device combin.:Local device is device		1 to 6	1
_:5131:122	Device combin.:Lowest appearing bit rate		• 64 kBit/s • 128 kBit/s • 512 kBit/s • 2048 kBit/s	64 kBit/s

Addr.	Parameter	C	Setting Options	Default Setting
Prot. interf.1				
_:5161:1	Prot. interf.1:Mode		• off • on	on
_:5161:105	Prot. interf.1:Max. error rate per hour		0.000 % to 100.000 %	1.000 %
_:5161:106	Prot. interf.1:Max. error rate per min		0.000 % to 100.000 %	1.000 %
_:5161:107	Prot. interf.1:Disturbance alarm after		0.05 s to 2.00 s	0.10 s
_:5161:108	Prot. interf.1:Transm. fail. alarm after		0.0 s to 6.0 s	6.0 s
_:5161:109	Prot. interf.1:Delay time threshold		0.1 ms to 30.0 ms	30.0 ms
_:5161:110	Prot. interf.1:Difference Tx and Rx time		0.000 ms to 3.000 ms	0.100 ms
_:5161:113	Prot. interf.1:PPS synchronization		• telegr. and PPS • telegr. or PPS • PPS sync. off	PPS sync. off
Ext. Synchron.				
_:9181:114	Ext. Synchron.:PPS pulse loss alarm aft.		2.5 s to 60.0 s	2.5 s

3.5.3.12 Information List

No.	Information	Data Class (Type)	Type
Device combin.			
_:5131:52	Device combin.:Behavior	ENS	O
_:5131:53	Device combin.:Health	ENS	O
_:5131:301	Device combin.:Status of topo. recog.	ENS	O
_:5131:302	Device combin.:Topology is	ENS	O
_:5131:303	Device combin.:Devices found	INS	O
_:5131:304	Device combin.:Number of detect. dev.	INS	O
_:5131:305	Device combin.:Fct. logoff device 1	SPS	O
_:5131:306	Device combin.:Fct. logoff device 2	SPS	O
_:5131:307	Device combin.:Fct. logoff device 3	SPS	O
_:5131:309	Device combin.:Fct. logoff device 4	SPS	O
_:5131:310	Device combin.:Fct. logoff device 5	SPS	O
_:5131:311	Device combin.:Fct. logoff device 6	SPS	O
_:5131:312	Device combin.:Device 1 available	SPS	O
_:5131:313	Device combin.:Device 2 available	SPS	O
_:5131:314	Device combin.:Device 3 available	SPS	O
_:5131:315	Device combin.:Device 4 available	SPS	O
_:5131:316	Device combin.:Device 5 available	SPS	O
_:5131:317	Device combin.:Device 6 available	SPS	O
Prot. interf.1			
_:5161:81	Prot. interf.1:>Block stage	SPS	I
_:5161:500	Prot. interf.1:>Sync. reset	SPS	I
_:5161:341	Prot. interf.1:Reset synchronization	SPC	C
_:5161:342	Prot. interf.1:Reset measurements	SPC	C

No.	Information	Data Class (Type)	Type
_:5161:52	Prot. interf.1:Behavior	ENS	O
_:5161:53	Prot. interf.1:Health	ENS	O
_:5161:301	Prot. interf.1:Status of lay. 1 and 2	ENS	O
_:5161:302	Prot. interf.1:Status of lay. 3 and 4	ENS	O
_:5161:303	Prot. interf.1:Connection broken	SPS	O
_:5161:316	Prot. interf.1:Error rate / min exc.	SPS	O
_:5161:317	Prot. interf.1:Error rate / hour exc.	SPS	O
_:5161:318	Prot. interf.1:Time delay exceeded	SPS	O
_:5161:319	Prot. interf.1:Time delay different	SPS	O
_:5161:320	Prot. interf.1:Time delay jump	SPS	O
_:5161:321	Prot. interf.1:PI synchronized	SPS	O
_:5161:340	Prot. interf.1:Telegram lost	SPS	O
_:5161:308	Prot. interf.1:Tx tel/h	MV	O
_:5161:309	Prot. interf.1:Rx tel/h	MV	O
_:5161:310	Prot. interf.1:Tx tel/min	MV	O
_:5161:311	Prot. interf.1:Rx tel/min	MV	O
_:5161:312	Prot. interf.1:Tx err/h	MV	O
_:5161:313	Prot. interf.1:Rx err/h	MV	O
_:5161:314	Prot. interf.1:Tx err/min	MV	O
_:5161:315	Prot. interf.1:Rx err/min	MV	O
_:5161:334	Prot. interf.1:Miss.tel/min	MV	O
_:5161:335	Prot. interf.1:Miss.tel/h	MV	O
_:5161:336	Prot. interf.1:Miss.tel/d	MV	O
_:5161:337	Prot. interf.1:Miss.tel/w	MV	O
_:5161:338	Prot. interf.1:Av. Δt/d	MV	O
_:5161:339	Prot. interf.1:Av. Δt/w	MV	O
_:5161:331	Prot. interf.1:Recept.	MV	O
_:5161:323	Prot. interf.1:PPS: time del. unsym.	SPS	O
_:5161:324	Prot. interf.1:PI with PPS synchron.	SPS	O
_:5161:325	Prot. interf.1:Rec. Δt	MV	O
_:5161:326	Prot. interf.1:Sen. Δt	MV	O
_:5161:327	Prot. interf.1:Rec. Δt	MV	O
Ext. Synchron.			
_:9181:500	Ext. Synchron.:>Block stage	SPS	I
_:9181:501	Ext. Synchron.:>PPS pulse loss	SPS	I
_:9181:301	Ext. Synchron.:PPS pulse loss	SPS	O
_:9181:302	Ext. Synchron.:PPS pulse	SPS	O
Meas. val. dev.1			
_:1351:6811:300	Meas.val.dev.1:Dev.adr.	INS	O
_:1351:6811:301	Meas.val.dev.1:Line	ENS	O
_:1351:6811:302	Meas.val.dev.1:Vph	WYE	O
_:1351:6811:303	Meas.val.dev.1:Iph	WYE	O
Meas. val. dev.2			
_:1351:6841:300	Meas.val.dev.2:Dev.adr.	INS	O
_:1351:6841:301	Meas.val.dev.2:Line	ENS	O
_:1351:6841:302	Meas.val.dev.2:Vph	WYE	O

No.	Information	Data Class (Type)	Type
_:1351:6841:303	Meas.val.dev.2:Iph	WYE	O
Meas. val. dev.3			
_:1351:6871:300	Meas.val.dev.3:Dev.adr.	INS	O
_:1351:6871:301	Meas.val.dev.3:Line	ENS	O
_:1351:6871:302	Meas.val.dev.3:Vph	WYE	O
_:1351:6871:303	Meas.val.dev.3:Iph	WYE	O
Meas. val. dev.4			
_:1351:6901:300	Meas.val.dev.4:Dev.adr.	INS	O
_:1351:6901:301	Meas.val.dev.4:Line	ENS	O
_:1351:6901:302	Meas.val.dev.4:Vph	WYE	O
_:1351:6901:303	Meas.val.dev.4:Iph	WYE	O
Meas. val. dev.5			
_:1351:6931:300	Meas.val.dev.5:Dev.adr.	INS	O
_:1351:6931:301	Meas.val.dev.5:Line	ENS	O
_:1351:6931:302	Meas.val.dev.5:Vph	WYE	O
_:1351:6931:303	Meas.val.dev.5:Iph	WYE	O
Meas. val. dev.6			
_:1351:6961:300	Meas.val.dev.6:Dev.adr.	INS	O
_:1351:6961:301	Meas.val.dev.6:Line	ENS	O
_:1351:6961:302	Meas.val.dev.6:Vph	WYE	O
_:1351:6961:303	Meas.val.dev.6:Iph	WYE	O

3.6 Date and Time Synchronization

3.6.1 Overview of Functions

Timely recording of process data requires precise time synchronization of the devices. The integrated date/time synchronization allows the exact chronological assignment of events to an internally managed device time that is used to time stamp events in logs, which are then transmitted to a substation automation technology or transferred via the protection interface. A clock module internal to the device and having battery backup is synchronized cyclically with the current device time so that the right device time is available and used even in case of auxiliary-voltage failure. At the same time, this permits hardware-supported monitoring of the device time.

3.6.2 Structure of the Function

The integrated date/time synchronization is a supervisory device function. Setting parameters and indications can be found in the following menus for the DIGSI and the device:

Set date and time:

- DIGSI: Online access -> Interface -> Device -> Device Information -> Time Information
- Device: Main menu -> Device functions -> **Date & Time**

Parameter:

- DIGSI: Project -> Device -> Parameter -> **Time Settings**

Indications:

- DIGSI: Project -> Device -> Information routing -> Time keeping or Time Sync.

3.6.3 Function Description

Every SIPROTEC 5 device maintains an internal device time with date. The date and time can also be set on the device via the on-site operation panel or via DIGSI 5. Within a system, or even beyond, it is usually necessary to record the time of process data accurately and to have exact time synchronization of all devices. For SIPROTEC 5 devices, the sources of time and synchronization options can be configured.

Configurable Synchronization Options:

- **None (default setting)**
  The device functions without any external time synchronization. The internal time synchronization continues to work with the help of the back-up battery even when the auxiliary voltage is shut down temporarily. The time can be adjusted manually.
- **Telegram**
  The time is synchronized via a telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 or DNP3 protocol.
- **Connection to a radio clock**
  The time synchronization takes place with the set time telegram from an external receiver of IRIG-B received via the time synchronization interface of the device.
- **Ethernet**
  The time synchronization is done via Ethernet-based SNTP protocol (Simple Network Time Protocol), for example with IEC 61850 stations or via IEEE 1588. If you enable both services during configuration of Ethernet interfaces, these protocols are available as an option for the time synchronization.
- **Protection interface**
  The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management.

- Configured type of timer
- Indication of timer outage or failure
- Whether the device time is currently synchronized from the time source

The device-internal display or device time, which is continuously updated at the internal device time and the linked time source were synchronized at the time of telegram receipt, both displayed times are identical.

NOTE

All times displayed (also the time source) take into consideration the local time settings (zone and daylight saving time of the device) in the form of a numerical offset for UTC (universal time).

3.6.4 Application and Setting Notes

Parameter: Date Format

- Default setting Date format = YYYY-MM-DD

With the Date format parameter, you define the local customary format of the date display.

Parameter Value	Description
YYYY-MM-DD	Day.Month.Year: Typical European display Example: 24.12.2019
YYYY-MM-DD	Month/Day/Year: Typical US representation Example: 12/24/2019
YYYY-MM-DD	Year-Month-Day: Typical Chinese display Example: 2019-12-24

Parameter: Time zone time source 1,Time zone time source 2

- Default setting Time zone time source 1 = local, Time zone time source 2 = local

With the Time zone time source 1 and Time zone time source 2 parameters, you define the handling of time zones of the external timer.

Parameter Value	Description
local	Local time zone and daylight saving time are considered as time zone offsets to GMT.
UTC	Time format according to UTC (universal time)

Parameter: Time source 1,Time source 2

- Default setting Time source 1 = none, Time source 2 = none

With the Time source 1 and Time source 2 parameters, you can configure an external timer. The prerequisite is to have the corresponding hardware configuration of the communication interfaces of your SIPROTEC 5 device. This is listed as a profile when making a selection in DIGSI 5.

Parameter Value	Description
none	The time source is not configured.

Indication	Description
Device: Clock fail	This indication signals a high difference between the internally managed time and the time of the clock module that is not permissible. The triggering of the indication can point to a defect in the clock module or to an unacceptably high drift of the system quartz crystal. The time maintained internally is marked as invalid.
Time management: Daylight saving time	This indication signals whether daylight saving time has been enabled.
Time management: Clock set manually	This indication signals that the device time has been set manually via the on-site operation panel or via DIGSI 5.
Time synchronization: Status time source 1 Status time source 2	These 2 indications signal whether the active time sources are recognized as valid and active from the device point of view. When the indications get triggered, it can also be an indication that an incorrect configuration of the port or channel numbers was done at the on-site operation panel.
Time synchronization: Time sync. error	This indication signals after the parameterized time Fault indication after that synchronization using an external time source has failed.
Time synchronization: High accuracy	This indication signals that the device is synchronized with an accuracy better than 1 µs. The indication is only of significance when the PMU function is used.

NOTE

In case of a missing or discharged battery, the device starts without active external time synchronization with the device time 2011-01-01 00:00:00 (UTC).

For the device, DIGSI 5 provides a compact overview of the status of the time synchronization of your SIPROTEC 5 device in online mode. All displays are updated continuously. You can access the overview in the project-tree window via Online access.

DIGSI, Online access -> Interface -> Device -> Device Information -> Time Information

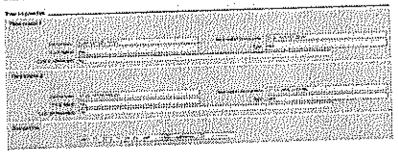

Figure 3-74 Time Information in DIGSI

For every time source, you see the following:

- Last received time (with date)
- Receipt time of the last received time telegram

Configurable Time Sources:

- 2 time sources can be taken into consideration with the SIPROTEC 5 devices. For each time source, the synchronization type may be selected based on the options provided.
- Time source 1 takes precedence over Time source 2, that is, Time source 2 will be effective for the synchronization of the device time only if Time source 1 fails. If only one time source is available and it fails, then only the internal clock continues unsynchronized. The status of the time sources is indicated.
- For every time source it is possible to define via the Time zone time source 1 parameter (or Time zone time source 2) if the source transmits its time by UTC (universal time) or if the settings correspond to the local time zone of the device.

NOTE

Make sure that the settings for the time sources coincide with the actual hardware configuration of your SIPROTEC 5 device. In any event, incorrect settings cause the status indications of time sources to pick up.

Configurable Date Format

Regardless of a feed time-synchronization source, a uniform format is maintained internally within the device. The following options are available for the customary local representation of the date format:

- Day.Month.Year: 24.12.2009
- Month/Day/Year: 12/24/2009
- Year-Month-Day: 2009-12-24

Taking Local Time Zones into Account

The internal device time is maintained in universal time (UTC). To display time stamps in DIGSI and on the device display, you can define the local time zone of the device (parameter Offset time zone for GMT), including the applicable daylight saving times (start, end, and offset of daylight saving time) using parameters. This allows the display of the local time.

NOTE

- For time sources that transmit the status of the switch to daylight saving time, this will be taken into account automatically when creating the internal device time in the UTC format. The differential time of the daylight saving time set in the device (parameter Offset daylight saving time) is taken into consideration. However, in contrast, the settings of the start of daylight saving time and end of the daylight saving times are ignored when converting into the device internal UTC format.
- For active time sources, it is not possible to set the time via the device display or DIGSI 5. An exception is setting the calendar year for active time protocol IRIG-B.

Status, Supervision, and Indications of Time Management

Your SIPROTEC 5 device generates status and monitoring indications that provide important information regarding the correct configuration of the time source and the status of the internal time management during start-up and device operation.

Internal time synchronization is monitored cyclically. Important synchronization processes, the status of the time sources and errors detected are reported. A device time that has become invalid will be marked accordingly so that affected functions can go to a safe state.

Parameter Value	Description
IRIG-B	Time synchronization by an external GPS receiver: SIPROTEC 5 devices support several protocol variants of the IRIG-B standards: • IRIG-B 002(003) The control function bits of the signal are not occupied. The missing year is formed from the current device time. In this case, it is possible to set the year via the online access in DIGSI 5. • IRIG-B 006(007) The bits for the calendar year are not equal to 00. The calendar year is set automatically by the time protocol. • IRIG-B 005(004) with extension according to IEEE C37.118-2005 If, in the time signal, other control function bits are occupied in addition to the calendar year, then the device takes the additional information into consideration for leap seconds, daylight saving time, time offset (zone, daylight saving time) and time accuracy. Time zone time source 1 or Time zone time source 2: The value of this setting is not evaluated by the device, since this protocol either transmits or in the case of local time, specifies the appropriate offset to UTC in each set time telegram.
DCF77	Time synchronization by an external DCF 77 receiver Time zone time source 1 or Time zone time source 2 = local Please note: There are also clocks that generate a DCF 77 signal representing UTC. In this case, UTC must be set.
PI	The time synchronization takes place via the protection interfaces configured for with SIPROTEC 5 device. Here, the timing master takes over the time management. Signal-transit times of the protection interface communication are calculated automatically. Time zone time source 1 or Time zone time source 2 = UTC A slave that receives a time of a SIPROTEC 5 master, receives its system time kept in UTC.
SNTP	The time synchronization is done via the Ethernet service SNTP (SNTP server or via IEC 61850). SIPROTEC 5 devices support both Edition1 and Edition2 in accordance with IEC 61850-7-2. In Edition2, the logical attributes LeapSecondsKnown, ClockFailure, ClockNotSynchronized, and the value TimeAccuracy are maintained in each time stamp. For Edition1, these signals contain default settings. Thus, the interoperability for substation automation technology is ensured for both editions! The SNTP service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. Time zone time source 1 or Time zone time source 2 = UTC
IEC 60870-5-103	The time is synchronized via telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 protocol. Time zone time source 1 or Time zone time source 2 = local However, there are also T103 systems that send the UTC.

Parameter Value	Description
DNP3	The time is synchronized via telegram with the appropriately configured communication interface in accordance with the DNP3 protocol. Two characteristics are supported in the process: • Time synchronization via UTC • Time synchronization with local time The daylight saving time status is not transmitted. The device assumes that the DNP3 master follows the same rules for the start and end of the daylight saving time as those that were set for the device. Time zone time source 1 or Time zone time source 2 = UTC is the current implementation. local concerns older implementations.
IEEE 1588	Time is synchronized via an IEEE 1588 timing master. In this case, SIPROTEC 5 devices operate as slave-only clocks. IEEE 1588 v2 is supported with P2P and Ethernet Transport. The IEEE 1588 service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. Time zone time source 1 or Time zone time source 2 = UTC

Parameter: Fault indication after

- Default setting Fault indication after = 600 s

With the Fault indication after parameter you set the time delay after which the unsuccessful attempts of time synchronization with external time sources configured are indicated.

Parameter: Time Zone and Daylight Saving Time

This parameter block contains all the settings for the local time zone and daylight saving time of your SIPROTEC 5 device. In addition to the individual parameters, configure the basic settings by preselecting via the radio buttons or check box.

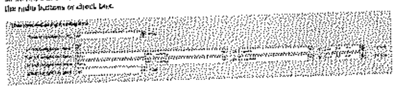

Figure 3-75 Settings for Time Zone and Daylight Saving Time in DIGSI

Selection Button	Description
Manual settings (local time zone and daylight saving time regulation)	This setting must be selected if you want to select the local time zone and daylight saving time zone regulations of your SIPROTEC 5 device regardless of the PC settings. Input: Offset time zone for GMT [min] Selection: Switchover to daylight saving time (yes/no) via check box ✓ Switch daylight sav. time • Input: Start of daylight saving time (Day and time) • Input: End of daylight saving time (Day and time) • Input: Offset daylight saving time [min] • Default settings as in the picture above

3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Time sync.				
_:102	Time sync.:Time source 1		• none • PPS • IRIG-B • DCF77 • Synchr. • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:103	Time sync.:Time source 1 port		• port J • port F • port E • port P • port N • port G	
_:104	Time sync.:Time source 1 channel		• Ch1 • Ch2	

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Addr.	Parameter	C	Setting Options	Default Setting
_:105	Time sync.:Time source 2		• none • PPM • IRIG-B • DCF77 • Synchrophasor • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:106	Time sync.:Time source 2 port		• port J • port F • port E • port P • port N • port G	
_:102	Time sync.:Time source 2 channel		• Ch1 • Ch2	
_:108	Time sync.:Time zone time source 1		• UTC • local	local
_:109	Time sync.:Time zone time source 2		• UTC • local	local
_:101	Time sync.:Fault indication after		0 s to 3600 s	600 s

3.6.6 Information List

No.	Information	Data Class (Type)	Type
Time managem.			
_:300	Time managem.:Daylight saving time	SPS	O
_:301	Time managem.:Clock set manually	SPS	O

No.	Information	Data Class (Type)	Type
Time sync.			
_:303	Time sync.:Status time source 1	SPS	O
_:304	Time sync.:Status time source 2	SPS	O
_:305	Time sync.:Time sync. error	SPS	O
_:306	Time sync.:Leap second	SPS	O
_:307	Time sync.:High accuracy	SPS	O

3.7 User-Defined Objects

3.7.1 Overview

Within a User-defined function group, you can use the User-defined function block and the User-defined function block [Control] to group user-defined objects that you find in the DIGSI 5 library under User-defined functions.

With user-defined function groups and user-defined functions, a grouping of user-defined objects, for example, user-defined function blocks, can be performed. 2 user-defined function blocks are available (see following figures).

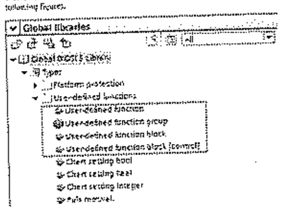

Figure 3-76 User Defined Objects at the DIGSI 5 Library

You can insert single-point indications, pickup and operate indications (ACD, ACT), single or double commands, commands with a controllable whole number as well as measured values in the User-defined function block (see following figure). You can assign a superordinate name to the grouping (for example, Process indications, for a group of single-point indications that are read in via binary inputs). This function can be deactivated via the mode. Readiness is also evaluated and represented.

The user defined function can be instantiated both at the highest level (in parallel to other function groups) and within the function groups and functions.

A User-defined function block [control] is also available. In addition to the mentioned option of a general User defined function block, this block offers additional tests for user-defined control signals, for example, SPC or DP.

You can find more information in chapter 2.4.1 Overview of Functions.

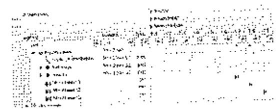

Figure 3-77 Information Routing Through the of Added User-Defined Function Block: Process Indications and Single-Point Indications

3.7.2 Basic Data Types

The following data types are available for user-defined objects in the DIGSI 5 library under the heading User-defined signals.

Single-Point Indication (Type SPS: Single-Point Status)

The status of a binary input can be registered in the form of a single-point indication or forwarded as the binary result from a CFC chart.

EXAMPLE

Acquisition using binary input, further processing in a CFC and/or signaling using an LED.

Single-Point Indication (Type SPS unsaved: Single-Point Status Unsaved)

In contrast to SPS single-point indications, the state of the SPS unsaved indication is not maintained after the device restarts.

For this purpose, go to **Properties > Details > Initialization > Restart** and set the **Value**.

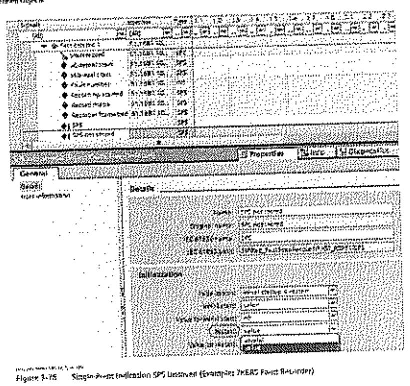

Figure 3-78 Single-Point Indication SPS Unsaved (Example: 7KE85 Fault Recorder)

Double-Point Indication (Type DPS: Double-Point Status)

When using a double-point indication, the status of 2 binary inputs can be captured simultaneously and mapped in an indication with 4 possible conditions (ON, Intermediate position, OFF, Disturbed position).

EXAMPLE

Acquisition of a disconnector or circuit-breaker switch position.

Marker Command (Type SPC, Single-Point Controllable)

This data type can be used as a command without feedback for simple signaling or as an internal variable (marker).

State of a Whole Number (Type INS)

The data type INS is used to create a whole number that represents a CFC result.

EXAMPLE

The output of the CFC block ADD_D can, for example, be connected with the data type INS. The result can be shown on the display of the device.

State of an Enumeration Value (Type ENS)

The data type ENS is used to create an enumerated value that represents a CFC result.

Controllable Single-Point Indication (SPC, Single-Point Controllable)

This can be used to issue a command (to one or several relays, selectable under information routing) that is monitored via a single feedback.

Command with Double-Point Feedback (DPC, Double-Point Controllable)

This can be used to issue a command (to one or several relays, selectable under information routing) that is monitored via double-point indication as feedback.

Command with a Whole Number (INC, Controllable Integer Status)

This can be used to issue a command (to one or more relays, selectable under information routing) that is monitored via a whole number as feedback.

Complex Measured Values (CMV)

This data type provides a complex measured value that can be used as a CFC result, for example.

Measured Values (MV)

This data type provides a measured value that can be used as a CFC result, for instance.

NOTE

Additional data types can be found under other headings in the DIGSI 5 library as well as in the corresponding function blocks. This applies to the following data types:

- Pulse-metered values (see User-defined functions in the DIGSI 5 library)
- Transformer taps
- Metered values

Phase-to-Ground Measured Values (WYE)

This data type represents the phase-to-ground measured values of a 3-phase system.

Phase-to-Phase Measured Values (DEL, Delta)

This data type represents the phase-to-phase measured values of a 3-phase system.

Protection Activation Information (ACT)

The object type is used by the protection functions for Tripping. It is available in the library for receiving protection information via the protection interface, which could also indicate Tripping.

Protection Activation Information with Direction (ACD)

This object type is used by the protection functions for Pickup. It is available in the library for receiving protection information via the protection interface, which could also indicate Pickup. In addition, both ACD and ACT can be generated and processed by CFC charts.

3.7.3 Pulse-Metered and Energy-Metered Values

Pulse-Metered Values

Pulse-metered values are available as data type BCR (Binary Counter Reading) in the function group Transformer as well as the function group Circuit breaker. There you will find Pulse-metered values under Measured values/User-defined values/Pulse-metered value.

The functionality and the settings of the pulse-metered values can be found in chapter 9.9.1 Pulse-Metered Values Function Description.

Energy-Metered Values

Energy-metered values no longer need to be created by the user separately. They are available as active and reactive power in each transformer function group for reference and output direction. The calculation is based on the current and voltage transformers associated with the transformer.

Detailed information can be found in the transformer function group in chapter 9.8.1 Function Description of Energy Values.

3.7.4 Additional Data Types

The following data types are also used in the system but are not available for general use as user-defined signals in the library:

- ENC (Enumerated Setting Controllable)
  The data type ENC models a command with which the user can set predefined values.
- SEQ (Sequence)
- BSC (Binary Controlled Step Position)
  The data type BSC can, for example, be used to control a transformer tap changer. The commands up, down can be given.

NOTE

Transformer taps are included in the Transformer tap changer switching element. If this switching element is created in the device, the transformer tap position is available as a data object of type BSC (binary controlled tap changer with tap position information).

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3.8 Other Functions

3.8.1 Signal Filtering and Chatter Blocking for Input Signals

Input signals can be filtered to suppress brief changes at the binary input. Chatter blocking can be used to prevent continuously changing indications from clogging the event list. After an adjustable number of changes, the indication is blocked for a certain period.

The settings for indication filtering can be found at the individual signals. The next figure shows the settings using the example of a controllable (circuit breaker switch position).

> **NOTE**
> For the circuit breaker or the disconnector, the settings of the software filter for spontaneous position changes are available only in the Control/Command with feedback function block. These settings are not available in the Circuit breaker or Disconnector function blocks since these function blocks contain the actual unfiltered position of the switch in the bay.

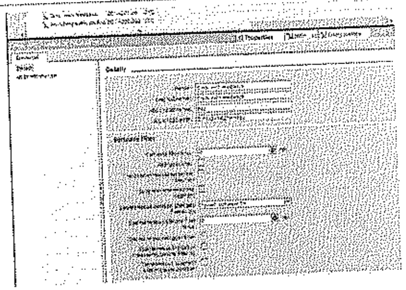

Figure 3-79 Settings for Circuit-Breaker Switch Position

The setting range for the Software filtering time parameter ranges from 0 ms to 86 400 000 ms (1 day) in ms increments. The Reset spor. filter check box can be used to select whether the software filter should be restarted by a change from 1 to 0 and back. When activated, the Indication timestamp before filtering check box back dates the time stamp by the set software filtering time and the fixed hardware filtering time. In this case, the time stamp corresponds to the actual status change of the signal. If you activate the Suppress intermediate position check box, the intermediate position is suppressed for the duration of this software filter time.

With the parameter Spontaneous position changes filtered by: you set how such position changes are to be filtered. Spontaneous position changes are caused by external switching commands, for

example. If the General software filter setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. The settings for spontaneous position changes can then not be edited. A separate filtering for spontaneous position changes is activated with the Spontaneous software filter setting and you can edit the settings for this.

Chatter blocking can be activated or deactivated as a parameter of the position in the Circuit breaker or Disconnector function block.

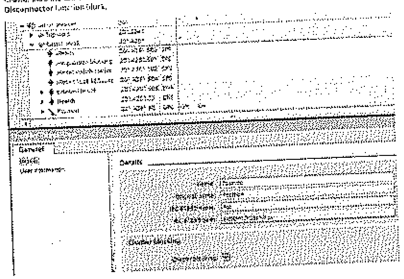

Figure 3-80 Setting Chatter Blocking

The settings for the chatter blocking function are set centrally for the entire device in DIGSI. They are accessible as settings in the General function group (see the following figure).

The chatter blocking settings have the following meaning (see also Figure 3-81 and Figure 3-82 in the examples shown in the following):

- No. permis.state changes
  This number specifies how often the state of a signal may toggle within the chatter-test time and the chatter-checking time. If this number is exceeded, the signal will be or remains blocked.
  Enter a number from 0 to 65535 in this field. If the entry is 0, chatter blocking is essentially inactive.
- Initial test time
  During this time, the number of times a signal changes its status is checked. This time is started if chatter blocking is configured for at least one signal and this signal changes its status. If the configured number of permissible state changes is exceeded during the initial test time, the signal is temporarily blocked and the indication Chatter block is set.
  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in seconds. When the set time has expired, the timer restarts automatically (cycle time).

- No. of chatter tests
  This number specifies the maximum number of test cycles to be run. If the number of permissible state changes stays exceeded during the initial test time of the last test cycle, the signal is finally blocked. In this case, the indication Group warning (Alarm handling group and Device group) are set additionally to the Chatter block indication after expiry of the set number. Restarting the device releases this lock again.
  Enter a number from 0 to 32767 in this field. The value Infinite (∞) is also permissible here.
  Enter this value as character string oo.
- Chatter idle time
  If the number of permissible status changes for a signal is exceeded during the initial test time or the subsequent test time, the Chatter idle time starts. Within this time, this signal is blocked temporarily and the Chatter blocking indication is set. The blocked input signal is assigned the oscillatory quality.
  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in minutes. An entry here is only considered if the number of chatter tests does not equal 0.
- Subsequent test time
  During this second test time, the number of times a signal changes its status is checked once again. The time begins when the Chatter idle time expires. If the number of status changes is within the permissible limits, the signal is released. Otherwise, an additional dead time begins, unless the maximum number of chatter tests has been reached.
  Enter a number between 2 and 65535 in this field. The number entered corresponds to the time in seconds. An entry here is only considered if the number of chatter tests does not equal 0.

Example 1: Permanent Blocking

The chatter blocking settings are set as follows:

- No. permis.state changes = 4
- No. of chatter tests = 2

After more than 4 state changes within the Initial test time, the input signal is set to the original state by the chatter blocking and the oscillatory quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the Chatter block indication is set. After expiry of the settable Chatter idle time, during the following Subsequent test time, it is checked whether the input signal is still chattering. This check is repeated, as the No. of chatter tests is set to 2 in this example.

If, during the 2nd Subsequent test time, it has been detected that the number of state changes of the input signal exceeds the set No. permis.state changes, the chatter blocking detects a persistent violation of the signal stability and sets the Group warning indication. The original state of the signal is permanently frozen. Only a device restart removes the chatter blocking again.

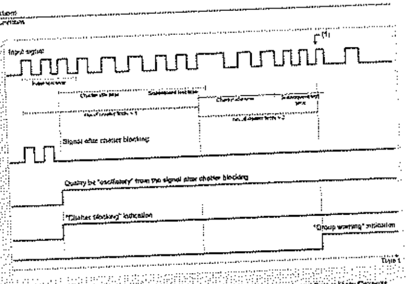

Figure 3-81 Signal Change during Chatter Blocking with too Important Number of Signal State Changes During 2nd Subsequent Test Time

(1) The input signal is permanently blocked starting from this point in time.

Example 2: Temporary Blocking

The chatter blocking settings are set as follows:

- No. permis.state changes = 4
- No. of chatter tests = 2

After more than 4 state changes within the Initial test time, the input signal is set to the original state by the chatter blocking and the oscillatory quality is assigned. Additionally, a corresponding indication is added to the operational log. At the same time, the Chatter blocking indication is set. After expiry of the settable Chatter idle time, during the following Subsequent test time, it is checked whether the input signal is still chattering. This check is repeated, as the No. of chatter tests is set to 2 in this example.

If, during the 2nd Subsequent test time, it has been detected that the number of state changes of the input signal is within the set No. permis.state changes, the temporary blocking of state changes of the signal is removed and the actual signal state is released.

The quality bit oscillatory is removed and the Chatter blocking indication is reset. As the temporary blocking of the signal is removed, the Group warning indication is not set. The chatter test starts again.

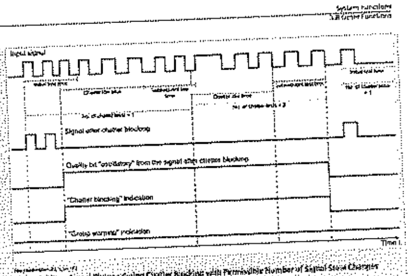

Figure 3-82 Signal Change during Chatter Blocking with Permissible Number of Signal State Changes During 2nd Subsequent Test Time

3.8.2 Acquisition Blocking and Manual Updating

During commissioning, maintenance, or testing, a brief interruption of the connection between the logical signals and binary inputs may be useful. It allows you to manually update the status of a switching device that is not providing feedback correctly. Before this can take place, you must first set acquisition blocking.

Set the Acquisition blocking function in the menu of the device display Commands > Equipment > Acq.blk man. update. If several switching devices are available, select the appropriate switching device. When pressing the Change key, the confirmation ID will be queried. After entering the confirmation ID, the Acquisition blocking function is switched on when OK is pressed.

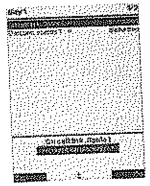

Figure 3-83 Activating the Acquisition Blocking

Manual updating of the switching device is possible from within the same menu. Use the menu item Change to select the Manual updating function. Subsequently, select the updating setting of the switching device manually and acknowledge the selection by pressing OK. The manually updated position of the switching device will be displayed.

Figure 3-84 Activate Manual Updating

Figure 3-85 Selecting Position

> **NOTE**
> For safety reasons, manual updating is possible only directly through the on-site operation panel of the device and not through DIGSI 5.

> **NOTE**
> Setting acquisition blocking and the subsequent manual updating are also possible via the IEC 61850 system interface.

Acquisition blocking can also be set via a binary input. This way, acquisition blocking can be set for an individual or several switching devices in a feeder simultaneously with an external toggle switch in order to

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disable the feeder. For this purpose, every switching device in the Switch function block (circuit breaker or disconnector switch) has the input signal >Acquisition blocking. This signal can also be set from the CFC.

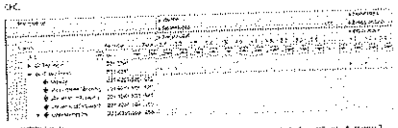

Figure 3-86 Input Signals >Acquisition Block and >Release Acquisition Block & Manual Update on the Switching Device

NOTE

Interlockings are carried out with the status changes of the switching device. Remove acquisition blocking again manually. Otherwise, position changes of the switching device are not detected and interlockings are ineffective.

If the acquisition blocking and the manually updated position are set using the operation panel at the device or the system interface IEC 61850, these are retained until the acquisition blocking is manually deactivated. When you initially start the device, the acquisition blocking is deactivated.

Except for a restart, the acquisition blocking and the manually updated position are retained.

If the acquisition blocking is activated via the input signal >Acquisition blocking, it is retained as long as the binary input is active.

To set the acquisition blocking of a switching device, the following sources are possible:

- Operation panel of the device
- System interface IEC 61850
- Input signal >Acquisition blocking

All sources undergo OR operations, that is, the acquisition blocking remains set until all the sources are deactivated.

After deactivation of the acquisition blocking, the actual position of the switching device is adopted and displayed in the operation panel of the device.

NOTE

When the acquisition blocking is activated or the switching device updated manually while the entire device or the switching device is in test mode, these states are not saved. The acquisition blocking and the manual updating are not retained after a restart.

Acquisition blocking and manual update for the circuit breaker, the disconnector and the tap changer are reset by way of the >Reset AcqBlk&Subst. binary input. Setting acquisition blocking and manual update is blocked with the input activated.

3.8.3 Persistent Commands

In addition to the switching commands, which are issued as pulse commands, and stored for the standard switching devices (circuit breaker, disconnector switch), persistent commands are also possible. In this case, a

distinction must be drawn between controllables with the Continuous output operating mode and a stored signal output that is immune to reset.

You can change a controllable from pulse to persistent command with the Command output parameter.

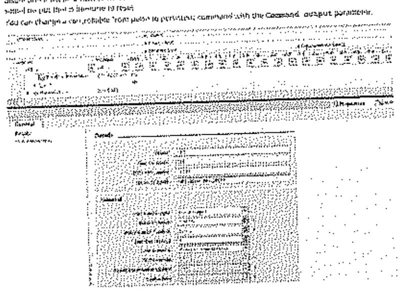

Figure 3-87 Setting the Command Type in DIGSI 5

Select Pulse output or Continuous output for the command output type. If a persistent command is selected, the Pulse parameter is irrelevant.

3.9 General Notes for Setting the Threshold Value of Protection Functions

3.9.1 Overview

You can set the threshold values of protection functions directly on the device or by using DIGSI 5.

An innovative design was implemented for the protection settings.

You can switch over the edit mode between the following setting views:

- Primary
- Secondary
- Percent

If you change settings in a setting view, DIGSI 5 calculates the settings of the 2 inactive views in the background. If you wish to save, for example, conversion to secondary values, then select the primary view. Configure all the settings and switch over to the secondary view.

Edit Mode: Primary

The parameters are set as primary values and thus refer directly to the primary system. The manual conversion on the secondary circuit is omitted.

Edit Mode: Secondary

The settings refer to the secondary circuit of the transformer. This means that the settings must be converted. The secondary setting is the customary setting view. For secondary tests, the pickup values can be read directly.

Edit Mode: Percent

This setting type is beneficial for electric machines (generators, transformers, motors, and busbars). The setting values can be standardized regardless of the machine size. The reference values for the percentage settings are the rated values of the function groups, for example, rated voltage and rated current or rated apparent power. The setting values are, thus, related exclusively to the primary settings. If other reference values are used, then this is documented for the respective protection function in the application and setting notes.

If parameters are recorded it may happen that they are set only as percent in all 3 setting views.

Recommendation for Setting Sequence

When setting the protection function, Siemens recommends the following procedure:

- First set the transformation ratios of the transformers. You can find these under Power-system data.
- In addition, set the reference parameters for the percent setting. You will find these parameters in function group, for example, in function group Transformer in General Nodes under Rated Values and Coil Data.
- Next, set the parameter of the protection functions.

  If the transformer data have changed after completing the protection setting, remain in the setting sheet (for example, primary setting) and change the transformer data. In the background, DIGSI 5 obtains the new settings in the inactive setting views (for example, new secondary values).

The following section explains, by way of an example, how to modify the transformer ratios in DIGSI 5 using the corresponding alternatives.

3.9.2 Modifying the Transformer Ratios in DIGSI 5

In the delivery setting, DIGSI 5 is set in the Secondary edit mode.

The following setting example shows how you can change the transformer ratio in DIGSI 5, and what impact this has on the settings in the setting views Primary and Secondary. The protection setting is observed in the example of the Overcurrent protection function.

The following output data are assumed:

Current transformer: 1000 A/1 A

Protection pickup value: 1.5 A

The following figure shows the protection setting of the Overcurrent protection function in the secondary view. The threshold value of the stage is set to 1.5 A.

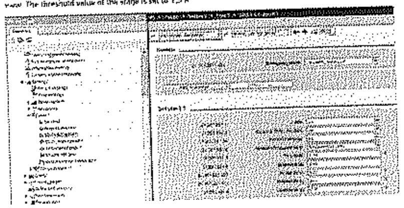

Figure 3-88 Protection Setting, Display of the Active Setting Sheet

When you click the green arrow in the setting sheet at the upper left, you get to the window for switching over to the setting view (see the following figure). Select the setting view you prefer.

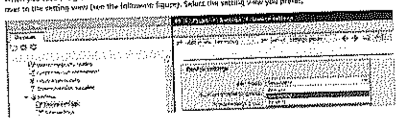

Figure 3-89 Switchover to the Desired Setting View

The following figures show the setting sequence in the Primary edit mode. Set the transformer data. In the example, the current transformer has a transformation ratio of 1000 A/1 A.

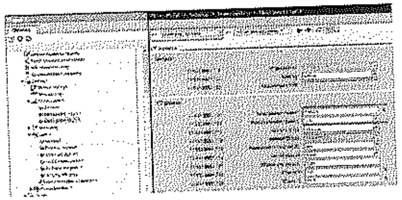

Figure 3-90 Setting Sheet Transformer Data

In the transformer function group, you set the transformer data (see the following figure). Rated current, rated voltage and rated apparent power are the reference variables for the percent setting.

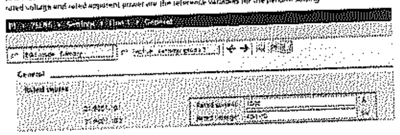

Figure 3-91 Reference Data for Percentage Settings

The following figure shows the threshold value of the Overcurrent protection function in the primary view at 1500 A.

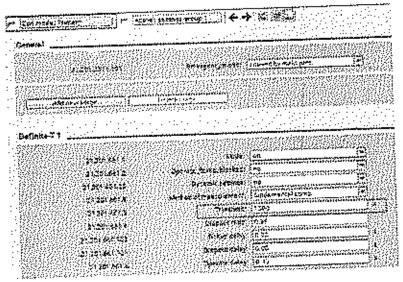

Figure 3-92 Example of the Threshold Value of the Definite-Time Overcurrent Protection (Edit Mode Primary)

When switching over to the percent view, the result should be the following value:

1500 A/1000 A · 100 % = 150 %

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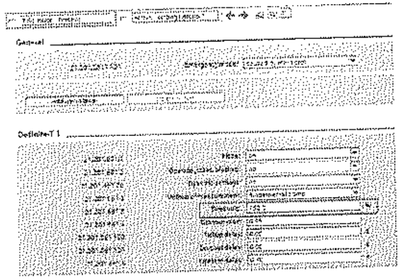

Figure 3-93 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Percent)

When switching over to the secondary view, the result should be the following value:
1500 A/(1000 A/1 A) = 1.5 A

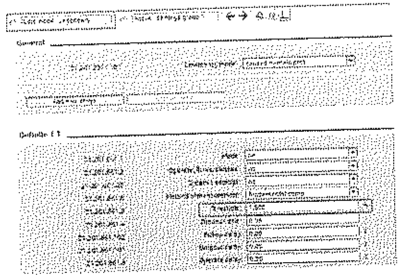

Figure 3-94 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Secondary)

If you only want to work in the secondary view, DIGSI 5 supports you if the transformer ratio changes during the project phase.
In the example, the current-transformer ratio changes from 1000 A/1 A to 1000 A/5 A. Change the secondary rated current of the current transformer in the setting sheet of the transformer data from 1 A to 5 A. If you change the transformer data, a window will appear (see the following figure) that will ask you for the action desired.

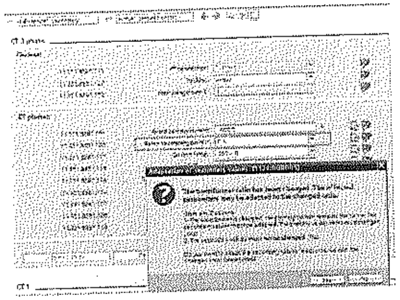

Figure 3-95 Query after Changing the Transformer Data (Setting View: Secondary)

If you answer the question with Yes, then DIGSI 5 will recalculate the pickup values (threshold values) in the active secondary view. For the new secondary transformer current 5 A, the new secondary threshold value obtained is 7.5 A (1.5 A * 5 = 7.5 A). The primary and percent values remain unchanged.
The following figure shows the newly calculated threshold value in the secondary view.

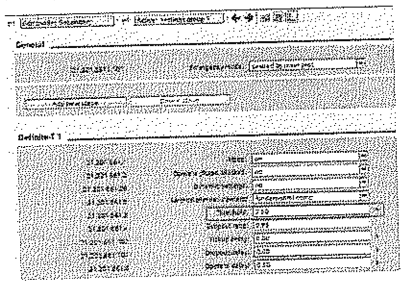

Figure 3-96 Automatically Recalculated Secondary Values After Changes in the Transformer Data

If you have already set the settings in the secondary view by including the new transformation ratio of the transformer in the calculation, then you answer the question with No. In this case, the protection settings in the secondary view remain unchanged. DIGSI 5 recalculates the settings (threshold values) of the primary view. In the example, the primary threshold value is then 300 A (1.5 A * 1000 A/5 A = 300 A).
In the example, the current-transformer ratio changes from 1000 A/1 A to 1000 A/5 A. The following table summarizes the pickup values that DIGSI 5 will recalculate in the setting view. The new values (in bold) depend on the answer of your inquiry (see Figure 3-95).

	Reply to the Question	
	Yes	No
Threshold value secondary (active setting view)	7.5 A	1.5 A
Threshold value primary (hidden setting view)	1500 A	300 A

3.9.3 Changing the Transformation Ratios of the Transformer on the Device

The device is preset to the secondary value at the time of delivery. Only secondary values can be set directly on the device.
If you change transformer data directly on the device, it is not followed by a query, like in DIGSI 5 (see Figure 3-95). Instead, the device assumes that all settings remain unchanged in the secondary view.

NOTE

If the device works with IEC 61850 protocol, you change the transformer data only via DIGSI 5 and not directly on the device. If you change the transformer data directly on the device, the IEC 61850 configuration of the measurement and metered values can be faulty.

3.10 Device Settings

3.10.1 Settings-Group Switching

3.10.1.1 Overview of Functions

For different applications you can save the respective function settings in so-called Settings groups, and if necessary enable them quickly.
You can save up to 8 different settings groups in the device. In the process, only one settings group is active at any given time. During operation, you can switch between settings groups. The source of the switchover can be selected via a parameter.
You can switch over the settings groups via the following alternatives:

- Via the on-site operation panel directly on the device
- Via an online DIGSI connection to the device
- Via binary inputs
- Via a communication connection to the substation automation technology.
  The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups.

A settings group includes all switchable settings of the device. Except for a few exceptions (for example, general device settings such as rated frequency), all device settings can be switched.
Detailed information about the settings groups can be found in the Operating Manual and DIGSI 5 Online Help.

3.10.1.2 Structure of the Function

The function of the Settings group switching is a superordinate device function. Accordingly, the settings and indications of the settings group switching can be found in DIGSI 5 and at the on-site operation panel of the device, below the general device settings respectively.
If you want to switch over a settings group, navigate in DIGSI 5 or proceed on the on-site operation panel of the device, as follows:

- Via the project tree in DIGSI 5:
  Project → Device → Settings → Device settings
- Via the on-site operation panel of the device:
  Main menu → Settings → General → Group switchover

The indications for the settings group switching can be found in the DIGSI 5 project tree under:
Project → Device → Information routing → General

3.10.1.3 Function Description

Activation

If you want to use the Settings group switching function, you must first set at least 2 settings groups in DIGSI 5 (parameter Number of settings groups > 1). You can set up a maximum of 8 settings groups. The settings groups set in DIGSI 5 are subsequently loaded into the device.

Mechanism of the Switchover

When switching over from one settings group to another, the device operation is not interrupted. With the Activat. of settings group parameter, you are either specifying a certain settings group or you allow switching via control (IEC 60870-5-103, IEC 61850) or via binary input.

Switching via Control

When using the Control function for switching, the settings groups can be switched via a communication connection from the substation automation technology, or via a CFC chart.
The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.
In order to use a CFC chart for switching, you must create a new CFC chart in DIGSI 5. Create the CFC chart in the DIGSI 5 project tree under Name of the device → Charts → Add new chart. Link the signals that control settings group switching in the CFC chart.

Switching via Binary Input

There are 3 appropriate input signals available for switching via binary inputs. These input signals allow selection of the settings group via a binary code. If one of the 3 signals changes, the signal image present will, after 100 ms (stabilization time), result in switching over to the appropriate settings group. If only 2 settings groups must be switched over, only 1 binary input is required. The following table shows the possible binary codes (BCD) and applicable settings groups (PG).

Table 3-20 Binary Codes of the Input Signals and Applicable Settings Groups

BCD Code via Binary Inputs	PG 1	PG 2	PG 3	PG 4	PG 5	PG 6	PG 7	PG 8
>PG selection bit 3	0	0	0	0	1	1	1	1
>PG selection bit 2	0	0	1	1	0	0	1	1
>PG selection bit 1	0	1	0	1	0	1	0	1

Copying and Comparing Settings Groups

In DIGSI 5, you can copy or compare settings groups with each other.
If you want to copy settings groups, select a source and target parameter group in DIGSI 5 in the device settings, and then start the copy process. The device settings can be found in the DIGSI 5 project tree under Project → Device → Settings → Device settings.
If you want to compare settings groups, it is possible to do so in all setting sheets for settings. You will then select in addition to the active settings group, a 2nd settings group for comparison. Active setting values and the comparable values are displayed next to each other. For settings that cannot be switched over, no comparable values are displayed.

Indication of Settings Group Switchings

Every settings group shows an applicable binary indication as well as its activation and deactivation. The process of settings group switching is also logged in the log for settings changes.

3.10.1.4 Application and Setting Notes

Parameter: Number settings groups

- Default setting (_:123) Number settings groups = 1

With the Number settings groups parameter, you can set the number of available settings groups; you can switch between these.

Parameter: Activat. of settings group

- Default setting (_:124) Activat. of settings group = settings group 1

With the Activat. of settings group parameter, you specify the settings groups that you want to activate, or the mechanisms via which the switchover is allowed. You can switch over only between the settings groups specified with the Number settings groups parameter. Parameter Value

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Parameter Value	Description
via control	The switchover between the settings groups can only be initiated via a communication connection from a substation automation technology or via a CFC chart. The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.
via binary input	The switchover between the settings groups functions exclusively via the binary input signals routed to the settings group switching.
settings group 1 ... settings group 8	They define the active settings groups. You can define the active settings groups in DIGSI 5, or directly on the device via the on-site operation.

3.10.1.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Change group				
_:113	General:Number settings groups		1 to 8	1
_:114	General:Activat. of settings group		• via control • via binary input • settings group 1 • settings group 2 • settings group 3 • settings group 4 • settings group 5 • settings group 6 • settings group 7 • settings group 8	settings group 1

3.10.1.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>SG choice bit 1	SPS	I
_:501	General:>SG choice bit 2	SPS	I
_:502	General:>SG choice bit 3	SPS	I
_:300	General:Act. settings group 1	SPC	C
_:301	General:Act. settings group 2	SPC	C
_:302	General:Act. settings group 3	SPC	C
_:303	General:Act. settings group 4	SPC	C
_:304	General:Act. settings group 5	SPC	C
_:305	General:Act. settings group 6	SPC	C
_:306	General:Act. settings group 7	SPC	C
_:307	General:Act. settings group 8	SPC	C

3.10.2 General Device Settings

3.10.2.1 Overview

In Device settings in DIGSI 5, you find the following general settings

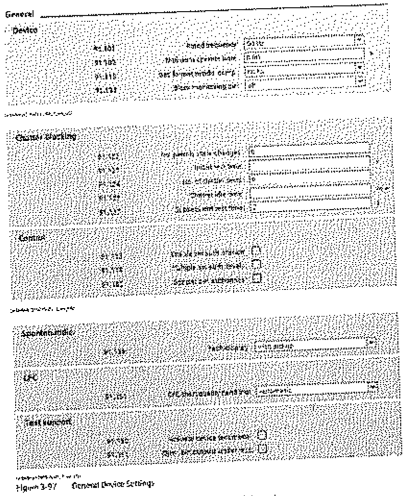

Figure 3-97 General Device Settings

The following list shows you the chapters containing the desired information.

You can find more about:

- Chatter blocking in chapter 3.8.7 Signal Filtering and Chatter Blocking for Input Signals .
- Control in chapter 7.1 Control Functionality .
- Spontaneous indications in chapter 3.1.7 Spontaneous Indication Display in DIGSI 5
- CFC Quality Processing in Chapter 3.2.4 Quality Processing/Affected by the User in CFC Charts .

Under Device, you set the parameters for the device that are valid across functions.

With the Test support, indications issued via communication interfaces are labeled with an additional test bit, if this is supported by the protocol. With this test bit, you can determine that an indication was generated in a test and that all or individual functions of the device are in test mode. In this way, the reactions that are necessary in normal operation due to an indication can be suppressed in other devices that receive these indications. You can also, for example, a trip command to close an energized binary output for test purposes. SIPROTEC 5 devices support the Test support only if after the first phase.

3.10.2.2 Application and Setting Notes

The major part of the settings is described in the chapters cited above. In the following sections, you can find a description of the parameters of the segments Device, Spontaneous indication, and Test support.

Parameter: Rated frequency

- Default setting (_:101) Rated frequency = 50 Hz

With the Rated frequency parameter, you set the rated frequency of the electrical power system.

Parameter: Minimum operate time

- Default setting (_:102) Minimum operate time = 0.00 s

With the Minimum operate time parameter, you set the minimum duration for the trip command of the functions. The trip command is maintained for the set duration.

Parameter: Set. format residu. comp.

- Default setting _:115 = Kr, Kx

With the parameter Set. format residu. comp., you specify the setting format for the residual compensation factors that applies across functions. You can set the residual compensation using the scalar factors Kr, Kx or as complex factors using K0 .

The setting format controls the visibility of the residual compensation factors in the Distance protection.

Parameter: Block monitoring dir.

- Default setting (_:138) Block monitoring dir. = off

With the Block monitoring dir. parameter, you set whether indications are issued via the system interface(s) of the SIPROTEC 5 device or not.

If transmission blocking is switched on, no indications are issued via the system interface(s) of a SIPROTEC 5 device.

Parameter: Fault-display

- Default setting (_:139) Fault-display = with pickup

With the Fault-display parameter, you set whether spontaneous indications are issued for a pickup or for a tripping. Keep the DIGSI 5 routing options in chapter 3.1.7 Spontaneous Indication Display in DIGSI 5 and Table 3-x in mind.

Parameter: Activate device test mode

- Default setting (_:150) Activate device test mode = inactive

With the Activate device test mode parameter, you activate the test mode that adds a test bit to the issued indications.

Parameter: Oper.bin.outp. under test

- Default setting (_:151) Oper.bin.outp. under test = inactive

If you activate the parameter Oper.bin.outp. under test , you can allow the closing of a binary output for test purposes. In this way, indications are issued during a device-wide test mode and the relays are either

activated or not. If an individual function is in test mode, only indications are issued and the relays are not activated.

> **NOTE**
>
> The device remains in test mode during every startup until you set the device back into process mode intentionally. You switch to the process mode by switching the parameter Activate device test mode to inactive again (removing the check mark).

3.10.2.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Device				
_:101	General:Rated frequency		• 50 Hz • 60 Hz	50 Hz
_:102	General:Minimum operate time		0.00 s to 60.00 s	0.00 s
_:115	General:Set. format residu. comp.		• Kr, Kx • K0	Kr, Kx
_:138	General:Block monitoring dir.		• off • on	off
Spontan. indic.				
_:139	General:Fault-display		• with pickup • with trip	with pickup
Test support				
_:150	General:Activate device test mode		• 0 • 1	false
_:151	General:Oper.bin.outp. under test		• 0 • 1	false

3.10.2.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:510	General:>Test mode on	SPS	I
_:511	General:>Test mode off	SPS	I
_:507	General:>Device funct.test off on	SPS	I
_:508	General:>Dev. funct.test off	SPS	I
_:512	General:>LED reset	SPS	I
_:52	General:Behavior	ENS	O
_:53	General:Health	ENS	O
_:51	General:Test mode	ENC	C
_:321	General:Protection on	SPC	C
_:54	General:Protection inactive	SPS	O
_:323	General:LED reset	SPC	C
_:320	General:LED have been reset	SPS	O

4 Applications

4.1 Overview

The Global DIGSI 5 library provides application templates for the applications of the devices. The application template

- Supports the fast realization of complete protection solutions for applications
- Contains the basic configuration for the use case
- Contains functions and default settings for the use case

Figure 2-1 in chapter 2 Basic Structure of the Function provides an example for the structure of an application template.

When using an application template, please note the following.

- Adapt the application template to your specific use (check/adapt default settings, delete/add functions). You can find more detailed information in the 2.1 Function Embedding in the Device .
- Check the routing of binary outputs with respect to fast and normal relays.
- Check the CFC charts for the group-warning indications and group-fault indications.

Application of the devices 7UT82, 7UT85, 7UT86, and 7UT87

The transformer differential protection 7UT8x is a selective short-circuit protection for transformers of all voltage series, for longitudinal and shunt reactors, as well as for short lines. The devices contain all functions that you need for protection from transformers and are therefore universally applicable. The main protection function of the devices is the differential protection.

The following describes the application templates and maximum functional scope for the devices 7UT82, 7UT85, 7UT86, and 7UT87.

> **NOTE**
>
> The availability of certain settings and setting options depends on the device type and the functions available on the device!

Number of Measuring Points

The following table shows you the maximum number of device-dependent current and voltage measuring points, which are available to you.

Table 4-1 Number of the Possible Measuring Points per Device

Device	Number of Measuring Points			
	I-3ph	I-1ph	V-3ph	V-1ph
7UT82	2	2	-	-
7UT85	5	1	1	2
7UT86	6	4	4	3
7UT87	9	5	5	3

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4.2 Application Templates and Functional Scope of the Device 7UT82

Application templates are available in DIGSI 5 for the applications of the device 7UT82. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7UT82 in the DIGSI 5 function library:

- 2-Winding Transformer Base (DIFF protection)
- 2-Winding Transformer (DIFF protection, CBFP, REF)
- Motor (DIFF protection)

To load the application templates to the device, the following minimum hardware configuration requirements must be met:

Application Templates		Hardware Configuration
Template 1	2-Winding Transformer Base (DIFF protection)	7 BI, 4 BO, 8 I (base module)
Template 2	2-Winding Transformer (DIFF protection, CBFP, REF)	7 BI, 4 BO, 8 I (base module)
Template 3	Motor (DIFF protection)	7 BI, 4 BO, 8 I (base module)

The following table shows the functional scope and the required function points of the application templates for device 7UT82:

Table 4-2 Functional Scope of the Application Template for the Device 7UT82

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3
37	Undercurrent protection	I<	X			
38	Temperature supervision	θ>	X			
46	Negative-sequence system overcurrent protection	I2>, I2/I1>	X			
	Unbalanced load protection (thermal)	I2²t	X			
49	Thermal overload protection	θ, I²t	X	X	X	X
49H	Hot-spot calculation	θh, I²t	X			
50/51 TD	Overcurrent protection, phases	I>, Ip>	X	X	X	X
50N/51N TD	Overcurrent protection, ground	IN>, INp>	X		X	
	Overcurrent protection, 1-phase	I1p>	X			
50Ns/51Ns	Sensitive ground-current protection for systems with resonant-grounded or isolated neutral	INs>, INsp>	X			
	Intermittent ground-fault protection	IIE>	X			
50HS	High-speed instantaneous overcurrent protection	I>>>	X			
	Instantaneous tripping at switch onto fault	SOTF	X			
50BF	Circuit-breaker failure protection	CBFP	X		X	

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3
50RS	Circuit-breaker restrike supervision	CBRM	X			
	Circuit-breaker supervision	ΣIx, I²t, 2P	X			
74TC	Trip-circuit supervision	AKU	X	X	X	X
86	Lockout		X	X	X	X
87G	Differential protection, generator	ΔI	X			
87M	Differential protection, motor	ΔI	X			X
87T	Differential protection, transformer	ΔI	X	X	X	
	Differential protection for phase-angle regulating transformers (single core)	ΔI	X			
87T Node	Transformer differential protection (node protection for auto transformer)	ΔI nodes	X			
87N T	Restricted ground-fault protection	ΔIN	X		X	
ARC	Arc protection	ARC	X			
	Measured values, standard		X	X	X	X
	Measured values, extended: Min, Max, Avg (function points per type)		X			
	Switching statistic counters		X	X	X	X
	CFC standard		X	X	X	X
	CFC arithmetic		X			
	CFC switching sequences		X			
	Inrush-current detection		X	X	X	X
	External trip initiation		X			
	Control for 4 switching devices		X	X	X	X
	Fault recording of analog and binary signals		X	X	X	X
	Monitoring and supervision		X	X	X	X
	Protection interface, serial		X			
	Circuit breaker		X	X	X	X
	Disconnector/grounding conductor		X			
Function points:				0	30	0

Application Template: 2-Winding Transformer Base (DIFF protection)

The application template 2-winding transformer Base (DIFF protection) is preconfigured for the following applications:

- Transformer differential protection (default setting for YY)
- Overload protection, backup protection for the downstream electrical power system

Application Template: 2-Winding Transformer (DIFF Protection, CBFP, REF)

The application template 2-winding transformer (DIFF protection, CBFP, REF) is preconfigured for the following applications:

- Transformer differential protection (default setting for YD)
- Restricted ground-fault protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

Application Template: Motor (DIFF Protection, CBFP)

The Motor (DIFF protection, CBFP) application template is preconfigured for the following applications:

- Differential motor protection
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

The following Figure 4-1 shows the structure of the application template Transformer protection with restricted ground-fault protection, the measuring points used, the function groups used, their internal circuiting and the predefined functions.

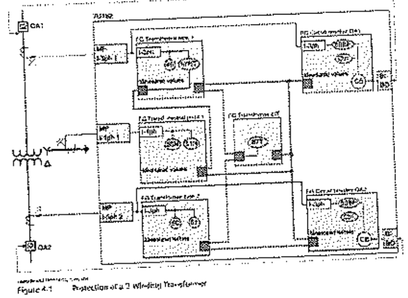

Figure 4-1 Protection of a 2-Winding Transformer

4.3 Application Templates and Functional Scope of the Device 7UT85

Application templates are available in DIGSI 5 for the applications of the device 7UT85. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7UT85 in the DIGSI 5 function library:

- 2-Winding Transformer Base (DIFF protection)
- 2-Winding Transformer (DIFF protection, CBFP, REF)
- 2-Winding Transformer 1.5 CB (DIFF protection, CBFP, REF)
- 2-Winding Transformer (DIFF protection, voltage controller)
- Motor (Diff. Protection, CBFP)

To load the application templates to the device, the following minimum hardware configuration requirements must be met:

Application Templates		Hardware Configuration
Template 1	2-Winding Transformer Base (DIFF protection)	7 BI, 7 BO, 8 I (base module)
Template 2	2-Winding Transformer (DIFF protection, CBFP, REF)	7 BI, 7 BO, 8 I (base module)
Template 3	2-Winding Transformer 1.5 CB (DIFF protection, CBFP, REF)	Base module + expansion module with current inputs (for example, IO203)
Template 4	2-Winding Transformer (DIFF protection, voltage controller)	7 BI, 7 BO, 8 I (base module)
Template 5	Motor (DIFF protection, CBFP)	7 BI, 7 BO, 8 I (base module)

The following table shows the functional scope and the required function points of the application templates for device 7UT85.

Table 4-3 Functional Scope of the Application Template for the Device 7UT85

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
21/21N	Distance protection	Z<, V< /I>/∠(V,I)	X					
	Distance protection (RMD)		X					
21T	Impedance protection for transformers	Z<	X					
24	Overexcitation protection	V/f	X					
25	Synchrocheck, synchronization function	Sync	X					
27	Undervoltage protection, 3-phase	V<	X					
	Undervoltage protection, positive-sequence system	V1<	X					
	Undervoltage protection, universal	Vx<	X					
27/Q	Directional reactive-power undervoltage protection	Q>/V<	X					
32/37	Power protection active/reactive power	P<>, Q<>	X					
32R	Reverse power protection	-P<	X					
37	Undercurrent protection	I<	X					
38	Temperature supervision	θ>	X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
46	Negative-sequence system overcurrent protection	I2>, I2/I1>	X					X
	Unbalanced-load protection (thermal)	I2²t	X					
47	Overvoltage protection, negative-sequence system	V2>	X					
	Overvoltage protection, negative-sequence system/positive-sequence system	V2/V1>	X					
49	Thermal overload protection	θ, I²t	X	X	X	X	X	X
49H	Hot-spot calculation	θh, I²t	X					
50BF	Circuit-breaker failure protection	CBFP	X		X	X	X	X
50RS	Circuit-breaker restrike supervision	CBRM	X					
	Circuit-breaker supervision	ΣIx, I²t, 2P	X					
50/51 TD	Overcurrent protection, phases	I>, Ip>	X	X	X	X	X	X
50N/51N TD	Overcurrent protection, ground	IN>, INp>	X		X			
	Overcurrent protection, 1-phase	I1ph>	X			X		
50Ns/51Ns	Sensitive ground-current protection for systems with resonant-grounded or isolated neutral	INs>, INsp>	X					
	Intermittent ground-fault protection	IIE>	X					
50HS	High-speed instantaneous overcurrent protection	I>>>	X					
51V	Voltage-controlled overcurrent protection	t = f(I,V)	X					
59	Overvoltage protection, 3-phase	V>	X					
	Overvoltage protection, positive-sequence system	V1>	X					
	Overvoltage protection, universal	Vx>	X					
59N	Overvoltage protection, zero-sequence system	V0>	X					
67	Directional time-overcurrent protection, phases	I>, Ip ∠ (V,I)	X					X
67N	Directional time-overcurrent protection, ground	IN>, INp ∠ (V,I)	X					
67Ns	Sensitive ground-fault detection for resonant-grounded and isolated systems with • V0> • cos φ/sin φ • Fleeting contact • φ(V,I) • Admittance	INs> ∠(V,I), W0p, tr>	X					
	Directional intermittent ground-fault protection	IIEdir>	X					
68	Power-swing blocking	ΔZ/Δt	X					
74TC	Trip-circuit supervision	AKU	X	X	X	X	X	
79	Automatic reclosing AREC, 3-pole	AREC	X					
81O	Overfrequency protection	f>	X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
81U	Underfrequency protection	f<	X					
81R	Rate-of-frequency-change protection	df/dt	X					
85/21	Teleprotection scheme for distance protection		X					
85/27	Weak or no infeed: Echo and tripping		X					
85/67N	Teleprotection scheme for directional ground-fault protection		X					
86	Lockout		X	X	X	X	X	
87G	Differential protection, generator	ΔI	X					
87L	Line differential protection for 2 line ends	ΔI	X					
87M	Differential protection, motor	ΔI	X					X
87 STUB	Stub differential protection (for 1 1/2 circuit-breaker applications)		X					
	Option for differential protection: charging-current compensation	ΔI	X					
87T	Differential protection, transformer	ΔI	X	X	X	X	X	
	Differential protection for phase-angle regulating transformers (single core)	ΔI	X					
	Differential protection for special transformers	ΔI	X					
87T Node	Transformer differential protection (node protection for auto transformer)	ΔI nodes	X					
87N T	Restricted ground-fault protection	ΔIN	X		X	X		
90V	Two-winding transformer voltage controller		X				X	
	Three-winding transformer voltage controller		X					
	Grid coupling transformer voltage controller		X					
FL	Fault locator, single-ended	FL-one	X					
PMU	Synchrophasor measurement	PMU	X					
SOTF	Instantaneous tripping at switch onto fault	SOTF	X					
ARC	Arc protection	ARC	X					
	Measured values, standard		X	X	X	X	X	X
	Measured values, extended: Min, Max, Avg (function points per type)		X					
	Switching statistic counters		X	X	X		X	X
	CFC standard		X	X	X	X	X	X
	CFC arithmetic		X					
	CFC switching sequences		X					
	Inrush-current detection		X	X	X	X	X	X
	External trip initiation		X				X	
	Control for 4 switching devices		X	X	X	X	X	
	Fault recording of analog and binary signals		X	X	X	X	X	

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ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
	Monitoring and supervision		X	X	X	X	X	
	Protection interface, serial		X					
	Circuit breaker		X	X	X	X	X	
	Disconnector/grounding conductor		X					
Function points:				0	60	40	120	50

Application Template: 2-Winding Transformer Base (DIFF Protection)

The application template 2-winding transformer Base (DIFF protection) is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd)
- Overload protection, backup protection for the downstream electrical power system

Application Template: 2-Winding Transformer (DIFF, Protection, CBFP, REF)

The application template 2-winding transformer (DIFF protection, CBFP, REF) is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd)
- Restricted ground-fault protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit breaker failure protection

Application Template: 2-Winding Transformer 1.5 CB (DIFF Protection, CBFP, REF)

The application template 2-winding transformer 1.5 CB (DIFF protection, CBFP, REF) is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd)
- Restricted ground-fault protection on the star side
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

Application Template: 2-Winding Transformer (DIFF Protection, Voltage Controller))

The application template 2-winding transformer (DIFF protection, voltage controller) is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd)
- Overload protection, backup protection for the downstream electrical power system
- Voltage controller

Application Template: Motor (DIFF Protection, CBFP)

The Motor (DIFF protection, CBFP) application template is preconfigured for the following applications:

- Differential motor protection
- Overload protection, backup protection for the downstream electrical power system
- Circuit breaker failure protection

The following Figure 4-2 shows the structure of the application template **Transformer protection with restricted ground-fault protection**, the measuring points used, the function groups used, their internal circuiting and the predefined functions.

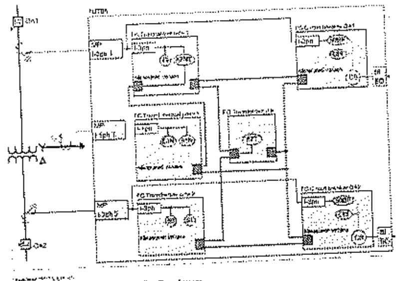

Figure 4-2 Protection of a 2-Winding Transformer

4.4 Application Templates and Functional Scope of the Device 7UT86

Application templates are available in DIGSI 5 for the applications of the device 7UT86. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7UT86 in the DIGSI 5 function library:

- 3-Winding transformer Base (DIFF protection)
- 3-Winding transformer 1.5 CB (DIFF protection, CBFP, REF)
- 3-Winding transformer (DIFF protection, CBFP, REF, DIS)
- Auto transformer (DIFF protection, CBFP, REF)
- Auto transformer 1.5 CB (2 DIFF protection, CBFP, voltage protection, frequency protection)

The application templates of a 2-winding application can also be used in a 7UT86.

You can find more information in chapter 4.3 Application Templates and Functional Scope of the Device 7UT85.

To load the application templates to the device, the following minimum hardware configuration requirements must be met:

Application Templates		Hardware Configuration
Template 1	3-Winding Transformer Base (DIFF protection)	11 BI, 19 BO, 12 I, 4 V
Template 2	3-Winding Transformer 1.5 CB (DIFF protection, CBFP, REF)	11 BI, 19 BO, 17 I, 4 V
Template 3	3-Winding Transformer (DIFF protection, CBFP, REF, DIS)	11 BI, 19 BO, 12 I, 4 V
Template 4	Auto Transformer (DIFF protection, CBFP, REF)	11 BI, 19 BO, 12 I, 4 V
Template 5	Auto Transformer 1.5 CB (2 DIFF protection, CBFP, voltage protection, frequency protection)	23 BI, 34 BO, 12 I, 4 V

The following table shows the functional scope and the required function points of the application templates for device 7UT86:

Table 4-4 Functional Scope of the Application Templates for the Device 7UT86

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
21/21N	Distance protection	Z<, V< /I>/∠ (V,I)	X			X		
	Distance protection (RMD)		X					
21T	Impedance protection for transformers	Z<	X					
24	Overexcitation protection	V/f	X					
25	Synchrocheck, synchronization function	Sync	X					
27	Undervoltage protection, 3-phase	V<	X					
	Undervoltage protection, positive-sequence system	V1<	X					
	Undervoltage protection, universal	Vx<	X					
27/Q	Directional reactive-power undervoltage protection	Q>/V<	X					
32/37	Power protection active/reactive power	P<>, Q<>	X					
32R	Reverse-power protection	-P<	X					
37	Undercurrent protection	I<	X					
38	Temperature supervision	θ>	X					
46	Negative-sequence system overcurrent protection	I2>, I2/I1>	X					
	Unbalanced-load protection (thermal)	I2²t>	X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
47	Overvoltage protection, negative-sequence system	V2>	X					
	Overvoltage protection, negative-sequence system/positive-sequence system	V2/V1>	X					
49	Thermal overload protection	θ, I²t	X		X	X	X	X
49H	Hot-spot calculation	θh, I²t	X					
50BF	Circuit breaker failure protection	CBFP	X		X	X	X	X
50RS	Circuit-breaker restrike supervision	CBRS	X					
	Circuit-breaker supervision	ΣIx, I²t, 2P	X					
50/51 TD	Overcurrent protection, phases	I>, Ip>	X		X	X	X	X
50N/51N TD	Overcurrent protection, ground	IN>, INp>	X					
	Overcurrent protection, 1-phase	IN>	X		X	X	X	
50Ns/51Ns	Sensitive ground-current protection for systems with resonant-grounded or isolated neutral	INs>, INs>	X					
	Intermittent ground-fault protection	IIEF>	X					
50HS	High-speed instantaneous overcurrent protection	I>>>	X					
50N/51N TD	Overcurrent protection, 1 phase	IN>	X					
51V	Voltage-controlled overcurrent protection	t = f(I,V)	X					
59	Overvoltage protection, 3-phase	V>	X					
	Overvoltage protection, positive-sequence system	V1>	X					
	Overvoltage protection, universal	Vx>	X					
59N	Overvoltage protection, zero-sequence system	V0>	X					
67	Directional time-overcurrent protection, phases	I>, Ip ∠ (V,I)	X					
67N	Directional time-overcurrent protection, ground	IN>, INp ∠ (V,I)	X					
	Directional overcurrent protection for ground faults in grounded systems		X					
67Ns	Sensitive ground-fault detection for systems with resonant-grounded or isolated neutral, incl.: • V0> • cos-φ/sin φ • Floating contact • φ(V,I) • Admittance	INs>, ∠(V,I), W0p, tr>	X					
	Directional intermittent ground-fault protection	IIEF dir>	X					
68	Power-swing blocking	ΔZ/Δt	X					
74TC	Trip-circuit supervision		X	X	X	X	X	X
79	Automatic reclosing AREC, 3-pole	AREC	X					

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
81O	Overfrequency protection	f>	X					
81U	Underfrequency protection	f<	X					
81R	Rate-of-frequency-change protection	df/dt	X					
85/21	Teleprotection scheme for distance protection		X					
85/27	Weak or no infeed: Echo and tripping		X					
85/67N	Teleprotection scheme for directional ground-fault protection		X					
86	Lockout		X	X	X	X	X	X
87G	Differential protection, generator	ΔI	X					
87L	Line differential protection for 2 line ends	ΔI	X					
87M	Differential protection, motor	ΔI	X					
87 STUB	Stub differential protection (for 1 1/2 circuit-breaker applications)		X					
87T	Differential protection, transformer	ΔI	X	X	X	X	X	X
	Differential protection for phase angle regulating transformers (single core)	ΔI	X					
	Differential protection for special transformers	ΔI	X					
87T Node	Transformer differential protection (node protection for auto transformers)	ΔI (nodes)	X					X
87N T	Restricted ground-fault protection	ΔIN	X		X	X	X	
90 V	Two-winding transformer voltage controller		X					
	Three winding transformer voltage controller		X					
	Grid coupling transformer voltage controller		X					
FL	Fault locator, single-ended	FL-one	X					
PMU	Synchrophasor measurement	PMU	X					
SOTF	Instantaneous tripping at switch onto fault	SOTF	X					
AFD	Arc protection	ARC	X					
	Measured values, standard		X	X	X	X	X	X
	Measured values, extended: Min, Max, Avg (function points per type)		X					
	Switching statistic counters		X					
	CFC standard		X	X	X	X	X	X
	CFC arithmetic		X					
	CFC switching sequences		X					
	Inrush-current detection		X		X	X	X	X
	External trip initiation		X					
	Control for switching devices		X	X	X	X	X	X
	Fault recording of analog and binary signals		X	X	X	X	X	X

ANSI	Function	Abbr.	Available	Template 1	Template 2	Template 3	Template 4	Template 5
	Monitoring and supervision		X	X	X	X	X	X
	Protection interface, serial		X					
	Circuit breaker		X	X	X	X	X	X
	Disconnector/grounding conductor		X					
Function points:				0	45	150	30	30

Application Template: 3-Winding Transformer Basic (DIFF Protection)

The application template 3-winding transformer Basic (DIFF protection) is preconfigured for the following applications:

- Transformer differential protection (default setting for Yd

Application Template: 3-Winding Transformer 1.5 CB (DIFF Protection, CBFP, REF)

The application template 3-winding transformer 1.5 CB (DIFF protection, CBFP, REF) is preconfigured for the following applications:

- Transformer differential protection (default setting for YNd/d)
- Ground fault differential protection on the star side
- Ground current protection on the neutral side as backup protection for the electrical power system
- Overload protection
- Frequency and voltage protection on the neutral side
- Circuit-breaker failure protection

Application Template: 3-Winding Transformer (DIFF Protection, CBFP, REF, DIS)

The application template 3-winding transformer (DIFF protection, CBFP, REF, DIS) is preconfigured for the following applications:

- Transformer differential protection (default setting for YNd/d)
- Ground fault differential protection on the star side
- Ground current protection on the neutral side as backup protection for the electrical power system
- Overload protection
- Frequency and voltage protection on the neutral side
- Circuit-breaker failure protection
- Distance protection

Application Template: Auto Transformer (DIFF Protection, CBFP, REF)

The Auto transformer (DIFF protection, CBFP, REF) application template is preconfigured for the following applications:

- Transformer differential protection for the entire transformer (auto winding and stabilizing winding)
- Ground fault differential protection (neutral point and maximum side current)
- Overload protection, backup protection for the downstream electrical power system
- Circuit-breaker failure protection

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Application Template: Auto Transformer 1.5 CB (2 DIFF Protection, CBFP, Voltage Protection, Frequency Protection)

The Auto transformer 1.5 CB (2 DIFF protection, CBFP, voltage protection, frequency protection) application template is preconfigured for the following applications:

- Transformer differential protection for the entire transformer (auto winding and stabilizing winding)
- Intersection protection for the auto winding for recording ground faults (3-phase recording of the neutral point current)
- Overload protection, backup protection for the downstream electrical power system
- Frequency and voltage protection on the upper voltage side
- Circuit-breaker failure protection

To display the different, and at the same time new, options, 5 application templates are described in detail.

Application Template: 3-Winding Transformer in a Breaker-and-a-Half Layout

The 1st application is the template for protection of a three-winding transformer in a 1 1/2 circuit-breaker layout. You can recognize the 3 required function groups for the transformer side, the integration of the layout, as well as the internal connection and selected functions. In addition, a restricted ground-fault protection, as well as the internal connection and selected functions. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made depending on the system.

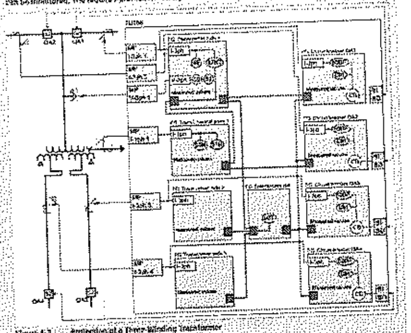

Figure 4-3 Protection of a Three-Winding Transformer

Application Template: Protection of an Auto-Transformer Bank in a Breaker-and-a-Half Layout

The 2nd application is the template for protection of an auto-transformer bank, which is connected in a 1 1/2 circuit-breaker layout. The special feature of this application is that per phase the neutral-point side current is directly recorded. A separate node-point differential protection for the auto winding reliably records ground faults and winding shorts. There are 2 differential protection functions (87T and 87T Node) assigned across the entire transformer (auto and stabilizing winding). Both functions run in the Auto transformer function group.

Through this type of execution you have a redundant differential protection supplemented in sensitivity. A separate restricted ground-fault protection is not required. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made depending on the system.

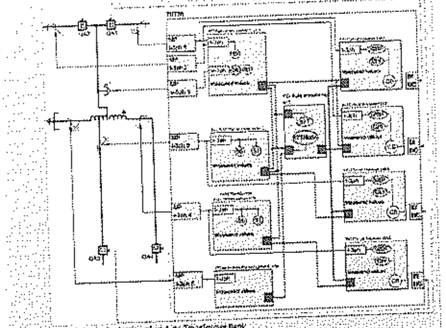

Figure 4-4 Protection of an Auto-Transformer Bank

Application Template: Motor Protection

The 3rd application is the template for motor protection. You can see the 2 function groups that are required for the motor sides as well as the internal interconnection and selected functions. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made depending on the system.

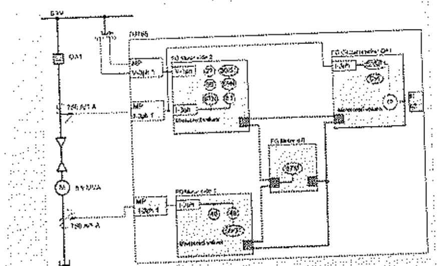

Figure 4-5 Motor Protection

Application Template: Control/Feedback Control of Power Transformers

The 4th application is the template for control/feedback control of power transformers (two-winding transformers, three-winding transformers, or grid coupling transformers) and auto transformers using a motor-operated tap changer with transformer voltage regulator functionality (ANSI 90 V).

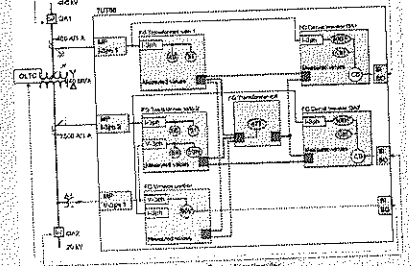

Figure 4-6 Transformer Protection with Voltage Control Functionality

Application Template: Protection of a Three-Winding Transformer with Distance Protection

The 5th application is the template for protection of a three-winding transformer. The neutral-point current of the upper-voltage side is measured and taken into account for the differential protection. In addition, restricted ground-fault protection is implemented for the upper-voltage side. A special feature of this application is the additional protection for the feeder on the 3rd side. The distance protection trips the circuit breaker for this feeder if there is a fault in the line. If the distance protection is only tripped at the node ZA non-directional due to the power system or error conditions, circuit breaker 1 of the transformer feed is tripped.

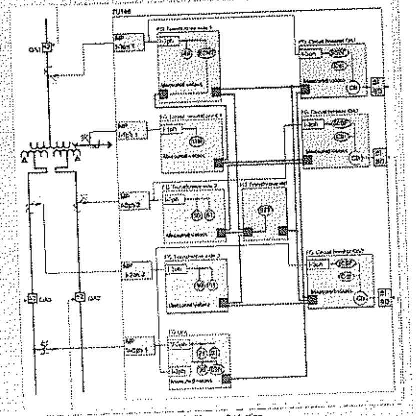

Figure 4-7 Three-Winding Transformer with Distance Protection

4.5 Application Templates and Functional Scope of the Device 7UT87

Application templates are available in DIGSI 5 for the applications of the device 7UT87. The application templates contain the basic configurations, required functions, and default settings.

All application templates, which were described for the devices 7UT82, 7UT85, and 7UT86, can be implemented in 7UT87.

Besides the functional scope of the 7UT86, the Differential protection for phase-angle regulating transformers (Two-Core PST) function is available.

The 7UT87 is intended for special applications (up to 5 sides and 7 measuring points), therefore, create your own application template depending on the application. Save this template with the device. To make your work easier, you can use an available template and modify it. Application suggestions can be taken from the device catalog Transformer Differential Protection 7UT82, 7UT85, 7UT86, 7UT87.

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5 Function-Group Types

5.1 Overview Function Group Transformer Differential Protection

5.1.1 Function-Group Types

In the following graphic, you can see the structural assumption of the function group types.

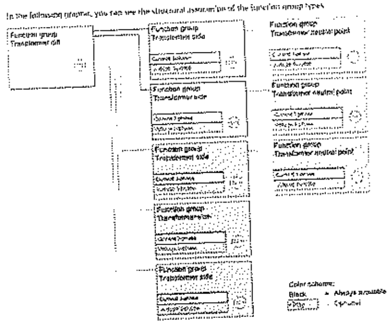

Figure 5-1 Transformer Diff Function-Group Types

The following function group types are summarized in the Global DIGSI 5 library:

- Transf. diff.
- Transformer side
- Transf. neutral point (transformer neutral point)

The individual function group types are stored in the Transformer diff function group folder and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. A Transf. diff. function group always contains 2 Transformer side function groups. The Transf. neutral point function group can be connected if needed with the Transformer side function group.

The following table shows the number of function-group types that can be instantiated depending on the device (7UT82, 7UT85, 7UT86, 7UT87).

> **NOTE**
> By purchasing 20 or 120 function points, the 7UT85 and 7UT86 can be expanded to a three-winding transformer or a multi-winding transformer. Provide the respective number of measuring inputs that are required for the expansion.

Table 5-1 Function-Group Types in the Device

Device	Function-Group Type		
	Transf. Diff.	Transformer Side	Transf. Neutral-Point Function Group
7UT82	Max. 1	Max. 2	Max. 2
7UT85	Max. 1	Max. 3 (2 open)	Max. 2
7UT86	Max. 1	Max. 4 (3 open)	Max. 3
7UT87	Max. 3	Max. 7	Max. 5

In order for the transformer protection to operate properly, switching of the function group is possible. Table 5-2 provides an overview of those switching options that are permitted. The Circuit-breaker function group is not listed. The figures shown in the application templates (see Figure 4-2 to Figure 4-7) offer a good overview of the interconnection options.

A Transformer side function group must always be connected with the Transformer diff. function group. Depending on the application, an interconnection of the Transf. neutral point function group with the Transformer side function group is required. This is the case, for example, if a restricted ground fault protection is used or if the neutral point current in the differential protection should be considered (residual current correction). The reverse can also be the case, that the Transf. neutral point needs signals from the Transf. diff. function group. A typical case is the inrush current detection, which can be used for blocking a 1-phase overcurrent protection (with a short time delay set).

Table 5-2 Assignment of Protection Function Groups to Protection Function Groups

Winding	Transf. Diff. 1	Transformer Side 1	Transformer Side 2
	Side (2 ... 5)	Neutral-Point Function Group (0 ... 3)	Neutral-Point Function Group (0 ... 1)
Transformer side 1	X	-	-
Transformer side 2	X	-	-
Transformer side 3[1]	X	-	-
Transformer side 4[2]	X	-	-
Transformer side 5[3]	X	-	-
Transf. neutral point 1	-	X	-
Transf. neutral point 2	-	-	X

The individual function-group types are described in the following.

5.1.2 Function-Group Type Transformer Differential Protection

5.1.2.1 Overview

The Transf. diff. function group contains the differential protection function and protection function relevant measured values.

You can find more information in chapter Measured values, Energy values, and Supervision of the Primary System.

You will find the corresponding function groups and also the folders with the usable protection functions in the Global DIGSI library under each device type. You can only load the differential protection function in the Transf. diff. function group.

[1] depending on device and application
[2] depending on device and application
[3] depending on device and application

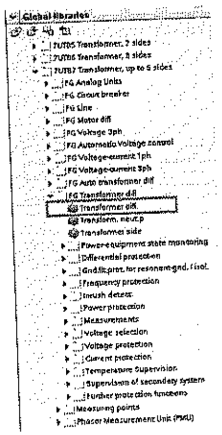

Figure 5-2 Transformer Diff. Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, please refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, please refer to chapter 4 Applications.

5.1.2.2 Structure of the Function Group

The Transf. diff. function group according to Figure 5-3 has interfaces with the Transformer side and Circuit-breaker function groups. The Transf. diff. function group contains the function blocks:

- Protection function (execution of the differential protection function)
- Trip logic (generation of forwarding of the operate indication)

In order for the protection functionality to be guaranteed, the differential protection function must always be present in the Transf. Diff. function group. If you do not use an application template, load this from the Global DIGSI 5 library.

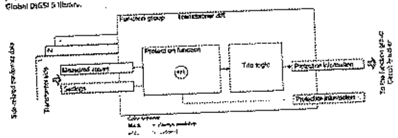

Figure 5-3 Structure of the Transformer Differential Function Group

The Transf. diff. function group has interfaces to the following function groups:

- Transformer side function group
- Circuit-breaker function group

Interface with the Transformer Side Function Group

The Transf. diff. function group receives the required measured values via the interface to the Transformer side function group. In addition, the required parameters are transferred.

When an application template is used, the Transf. diff. function group is connected with the required measuring points.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups.

The Transf. diff. function group is connected with one or more circuit-breaker function groups. This connection determines the following data:

- Which circuit breakers are activated by the protection functions of the Transf. diff. function group
- Start of the Circuit-breaker failure protection function, if available in the Circuit-breaker function group, through the protection functions of the connected protection function group Transf. diff.

In addition to the general assignment of the Transf. diff. function group to the Circuit-breaker function groups, you can configure the interface in detail for specific functionalities. Configure the details in DIGSI 5 using the Circuit-breaker interaction editor in the Transf. diff. function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Circuit-breaker failure protection function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with Protection communication. These data are for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.5 Protection Communication.

Transformer Data (Side-Related)

The transformer data characterize the data of the transformer to be protected. The Transf. diff. function group takes these data from the connected Transformer side function group.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately, in a pickup logic and an output logic respectively. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup and trip signals of the protection functions in the Transf. diff. function group are combined phase-selectively and output as a group indication.

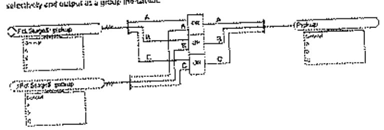

Figure 5-4 Generation of Pickup Indication of the Transf. Diff. Function Group

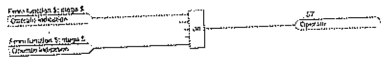

Figure 5-5 Generation of Operate Indication of the Transf. Diff. Function Group

5.1.2.3 Information List

No.	Information	Data class (type)	Type
General			
_:91:52	General: State	ENS	O
_:91:53	General: State	ENS	O
Group indication			
_:4501:55	Group indication: pickup	ACD	O
_:4501:57	Group indication: operate indication	ACT	O

No.	Information	Data class (type)	Type
Reset LED FG			
_:7381:500	Reset LED FG: >LED reset	SPS	I
_:7381:320	Reset LED FG: LED reset	SPS	O

5.1.3 Function-Group Type Transformer Side

5.1.3.1 Overview

In the Transformer side function group, all of the functions that are necessary for protecting and monitoring a transformer side can be used. The Transformer side function group also contains the measuring functions. You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.

The Transformer side function group must always have an interfacing to the Transformer function group. You will find the Transformer side function group and the folder with the respective protection functions under each device type in the Global DIGSI 5 library. Depending on the connected measuring points, you can insert the respective protection and supervision functions in the Transformer side function group. The application templates show you the possible applications. The functions are described in chapter 6 Protection and Automation Functions.

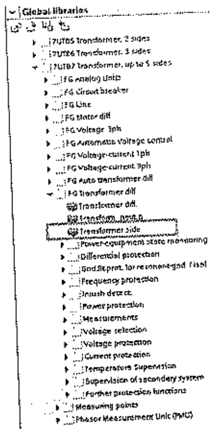

Figure 5-6 Transformer Side Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, please refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, please refer to chapter 4 Applications.

5.1.3.2 Structure of the Function Group

The Transformer side function group always contains the following function blocks:

- Side dependent transformer data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required for the Transformer side function group and therefore cannot be loaded or deleted. You can load the protection and supervision functions required for your application in the Transformer side function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

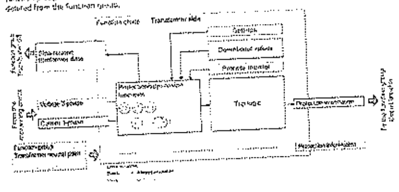

Figure 5-7 Structure of the Transformer Side Function Group

The Transformer side function group has interfaces with the following function groups: Measuring points

- Measuring points
- Circuit-breaker function group
- Transformer diff. function group
- Transformer neutral point function group

Interfaces with Measuring Points

The Transformer side function group receives the required measured values via its interfaces with the measuring points.

If you are using an application template, the Transformer side function group is connected to the necessary measuring points.

If you add functions to the Transformer side function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the Function group connections Editor.

You can find more detailed information in chapter 2 Basic Structure of the Function.

The Transformer side function group has the following interfaces with the measuring points:

- 3-phase voltage (optional):
  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.

- 3-phase current:
  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The Transformer side function group must always be linked to the I-3ph measuring point.
  You can connect the 3-phase current interface to a maximum of four 3-phase current measuring points, for example, for 1 1/2 circuit-breaker layouts, two 3-phase current measuring points are required. If 2 current measuring points have been connected to the 3-phase current interface, the total current is also determined from measured values from both measuring points in the Transformer side function group. All functions in the Transformer side function group have access to these total current values.

> **NOTE**
> The other interfaces can only be connected to one measuring point each.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

The Transformer side function group is connected to one or more circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the Transformer side protection function group
- Start of the Circuit-breaker failure protection function, if available in the circuit-breaker function group, through the protection functions of the connected Transformer side protection function group

Besides the general allocation of the Transformer side protection function group to the circuit-breaker function groups, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the Circuit-breaker interaction editor in the Transformer side function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Circuit-breaker failure protection function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Interface with Protection Communication (optional)

All required data is exchanged between the protection function group and the protection communication via the interface with Protection communication, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.6 Protection Communication.

Side-Dependent Transformer Data

The side dependent transformer data characterize the transformer side to be protected. The side dependent transformer data applies for all of the functions in the Transformer side function group.

Process Monitor

The process monitor is always present in the Transformer side function group and cannot be removed. The process monitor provides the following information in the Transformer side function group:

- Current flow criterion:
  Detection of an open/activated transformer side based on the flow of leakage current
- Closure detection:
  Detection of closure of the transformer side
- Cold-load pickup detection (optional).

This information is in the Transformer side function group and is available to all the functions in the function group.

The description of the process monitor begins in chapter 5.11 Process Monitor.

Operational Measured Values

The operational measured values are always present in the Transformer side function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. Only the first 3 lines apply for a 3-phase current connection.

Table 5-3 Possible Operational Measured Values of the Transformer Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_N	Measured neutral point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ obj.} \cdot I_{rated\ obj.}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ obj.} \cdot I_{rated\ obj.}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ obj.} \cdot I_{rated\ obj.}$

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the Transformer side function group are combined in a phase-selective manner and output as a group indication.

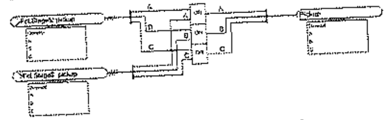

Figure 5-8 Generation of Pickup Indication of the Transformer Side Function Group

Figure 5-9 Generation of an Operate Indication of the Transformer Side Function Group

5.1.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

Depending on the protection function used and the circuit breakers to be activated, the connection to the corresponding Circuit breaker must be provided.

You can find more information in chapter 2 Basic Structure of the Function.

Parameter: Rated apparent power

- Default setting (_:9121:103) Rated apparent power = 692.82 MVA

With the Rated apparent power parameter, you can set the primary rated apparent power of the transformer to be protected.

> **NOTE**
> The windings for transformers with more than 2 windings can have different rated apparent powers. Here the power that is decisive for the winding, which is assigned to the side.

The Rated apparent power parameter is relevant for the main protection function of the device. The Rated apparent power set here is the reference value for the percentage-measured values and setting values made in percentages.

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NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting (_:91:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you can set the primary rated voltage of the transformer to be protected. The Rated voltage parameter is relevant for the main protection function of the device. The Rated voltage set here is the reference value for the percentage measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated current

- Default setting (_:91:101) Rated current = 1000 A

The Rated current parameter indicates to you the primary rated current of the transformer side. The Rated current parameter is relevant for the main protection function of the device. The setting value is formed from the Rated voltage and Rated apparent power parameters.

Parameter: Neutral point

- Default setting (_:91:149) Neutral point = grounded

With the Neutral point parameter, you specify whether the neutral point is grounded or isolated. If the neutral point is grounded via a ground current limiting (low-ohmic) or via a arc-suppression coil (high-ohmic), then also set grounded. If there is a neutral point former or a surge arrester within the protection range between the neutral point and ground, the neutral point also is valid as grounded.

Parameter: Winding configuration

- Default setting (_:91:104) Winding configuration = Y (Wye)

With the Winding configuration parameter, you set Y (Wye) for a star connection of the transformer. Other setting options are D (Delta) for a delta connection and Z (Zig-Zag) for a zigzag connection. The Winding configuration parameter is relevant for the main protection function of the device.

Parameter: Vector group numeral

- Default setting (_:91:100) Vector group numeral = 0

With the Vector group numeral parameter you set the vector group for the transformer to be protected. Each Vector group numeral from 0 to 11 can be set provided it is possible. For example, for Yy, Dd, and Dz, only even and for Yd, Yz, and Dy, only odd numbers are possible. The Vector group numeral parameter is relevant for the main protection function of the device.

NOTE

The device also automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the transformer to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the transformer.

Parameter: Side number

- Default setting (_:91:130) Side number = not assigned

The Side number parameter shows you which transformer side is currently valid for the following parameters. The side number (Side 1 to Side 5) is automatically assigned with the connection to a transformer side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting (_:91:210) MI3ph1 usesMeasP with ID = 0

The parameters MI3ph1 usesMeasP with ID to MI3ph4 usesMeasP with ID show you which 3-phase measuring points (MI3ph 1 to MI3ph 4) are connected to the transformer side. Every measuring point is assigned a unique ID.

Parameter: MI-1ph uses MeasP with ID

- Default setting (_:91:214) M I-1ph uses MeasP with ID = 0

The parameter M I-1ph uses MeasP with ID shows you which 1-phase measuring point is connected to the transformer side. Every measuring point is assigned a unique ID.

Parameter: Scale factor M I-3ph 1

- Default setting (_:91:215) Scale factor M I-3ph 1 = 0.000

The Scale factor M I-3ph 1 parameter shows you the magnitude scaling of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the transformer rated current of the side.

Parameter: Scale factor M I-3ph 1 IN

- Default setting (_:91:216) Scale factor M I-3ph 1 IN = 0.000

The Scale factor M I-3ph 1 IN parameter shows you the magnitude scaling of the ground current of the 1st assigned measuring point.

Parameter: Scale factor M I-3ph 2

- Default setting (_:91:217) Scale factor M I-3ph 2 = 0.000

The Scale factor M I-3ph 2 parameter shows you the magnitude scaling of the phase currents of the 2nd assigned measuring point.

Parameter: Scale factor M I-3ph 2 IN

- Default setting (_:91:218) Scale factor M I-3ph 2 IN = 0.000

The Scale factor M I-3ph 2 IN parameter shows you the magnitude scaling of the ground current of the 2nd assigned measuring point.

Parameter: Scale factor M I-3ph 3

- Default setting (_:91:219) Scale factor M I-3ph 3 = 0.000

The Scale factor M I-3ph 3 parameter shows you the magnitude scaling of the phase currents of the 3rd assigned measuring point.

Parameter: Scale factor M I-3ph 3 IN

- Default setting (_:91:220) Scale factor M I-3ph 3 IN = 0.000

The Scale factor M I-3ph 3 IN parameter shows you the magnitude scaling of the ground current of the 3rd assigned measuring point.

Parameter: Scale factor M I-3ph 4

- Default setting (_:91:221) Scale factor M I-3ph 4 = 0.000

The Scale factor M I-3ph 4 parameter shows you the magnitude scaling of the phase currents of the 4th assigned measuring point.

Parameter: Scale factor M I-3ph 4 IN

- Default setting (_:91:222) Scale factor M I-3ph 4 IN = 0.000

The Scale factor M I-3ph 4 IN parameter shows you the magnitude scaling of the ground current of the 4th assigned measuring point.

Parameter: Scale factor M I-1ph

- Default setting (_:91:223) Scale factor M I-1ph = 0.000

The parameter Scale factor M I-1ph shows you the magnitude scaling of the transformer neutral-point current.

5.1.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:91:101	General:Rated current		1 A to 100 000 A	1 000 A
Side data				
_:91:130	General:Side number		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:91:210	General:MI3ph 1 uses meas. pt. ID		0 to 100	0
_:91:211	General:MI3ph 2 uses meas. pt. ID		0 to 100	0
_:91:212	General:MI3ph 3 uses meas. pt. ID		0 to 100	0
_:91:213	General:MI3ph 4 uses meas. pt. ID		0 to 100	0
_:91:214	General:MI-1ph uses measuring point ID		0 to 100	0
_:91:215	General:Scale factor M I-3ph 1		0.010 to 100.000	0.000
_:91:216	General:Scale factor M I-3ph 1 IN		0.010 to 100.000	0.000
_:91:217	General:Scale factor M I-3ph 2		0.010 to 100.000	0.000
_:91:218	General:Scale factor M I-3ph 2 IN		0.010 to 100.000	0.000
_:91:219	General:Scale factor M I-3ph 3		0.010 to 100.000	0.000
_:91:220	General:Scale factor M I-3ph 3 IN		0.010 to 100.000	0.000

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:91:221	General:Scale factor M I-3ph 4		0.010 to 100.000	0.000
_:91:222	General:Scale factor M I-3ph 4 IN		0.010 to 100.000	0.000
_:91:223	General:Scale factor M I-1ph		0.010 to 100.000	0.000

NOTE

You can find more detailed information on the Process monitor in chapter 5.11 Process Monitor.

5.1.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:91:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:91:102	General:Rated voltage		0.40 kV to 800.00 kV	400.00 kV
Side data				
_:91:149	General:Neutral point		• grounded • isolated	grounded
_:91:104	General:Winding configuration		• Y (Wye) • D (Delta) • Z (Zig-Zag)	Y (Wye)
_:91:100	General:Vector group numeral		0 to 11	0
Measurements				
_:91:158	General:P, Q sign		• not reversed • reversed	not reversed

5.1.3.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

5.1.4 Function-Group Type Transformer Neutral Point

5.1.4.1 Overview

In the Transf. neutral point function group all the necessary functions for protection and for supervision of a transformer are used, which are related to a neutral-point current. The Transf. neutral point function group also includes the measurement functions. You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.

NOTE

The transformer and restricted ground-fault protection do not work with sensitive ground-current transformers. Responsive transformers up to saturation too fast and generate incorrect differential currents.

In the Global DIGSI 5 library you will find the Transf. neutral point function group under each device type and the folder with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the Transf. neutral point function group. Here you can only load 1-phase current functions or optional 1-phase voltage functions. The functions are described in chapter 6 Protection and Automation Functions.

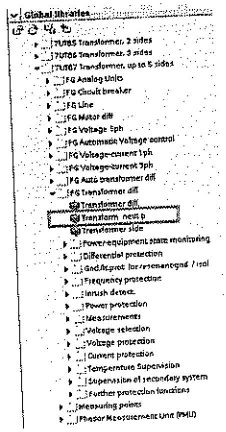

Figure 5-10 Transformer Neutral Point Function Group – Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, please refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, please refer to chapter 4 Applications.

5.1.4.2 Structure of the Function Group

The Transf. neutral point function group always includes the following function blocks:

- Neutral point oriented transformer data
- Operational measured values
- Output logic of the function group

These blocks are required in the Transf. neutral point function group and therefore cannot be loaded or deleted.

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You can load the protection and supervision functions required for your application in the Transf. neutral point function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

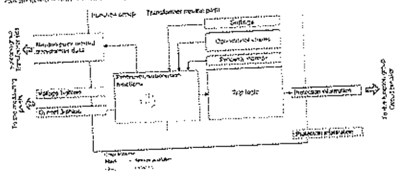

Figure 5-11 Structure of the Transf. Neutral Point Function Group

The Transf. neutral point function group has interfaces to the following function groups:

- Measuring points
- Circuit-breaker function group
- Transformer side

Interfaces with Measuring Points

The Transf. neutral point function group receives the required measured values via its interfaces with the measuring points.

When an application template is used, the Transf. neutral point function group is connected with the required measuring points.

If you insert functions in the Transf. neutral point function group, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the Function-group connections Editor.

You can find more detailed information in chapter 2 Basic Structure of the Function.

The Transf. neutral point function group has the following interfaces with the measuring points:

- 1-phase voltage (optional):
  The measurands from the 1-phase voltage system are supplied via this interface. All values that can be calculated from the measurands are also provided via this interface.
  If you want to test or change the connection between the voltages and the V-1ph measuring point, double-click Measuring point routing in the DIGSI 5 project tree → 7UT87(name of the device).
  For more information, please refer to the description of the Power System data starting from chapter 6.1 Power System Data.
  You must connect the 1-phase voltage interface with the Measuring point V-1ph only if functions in the Transf. neutral point function group work with this measurand.
- 1-phase current:
  The measurands from the 1-phase power system are supplied via this interface. Depending on type of transformer connection, this is, for example I_Y. All values that can be calculated from the measurands are also provided via this interface. The Transf. neutral point function group must always be linked with the Measuring point I-1ph

NOTE

You can connect the 1-phase current interface with a maximum of one 1-phase current measuring point.
All functions in the Transformer side function group have access to these values.

NOTE

If you instantiate functions in the Transf. neutral point function group, the Overcurrent protection 1ph function, the information for the inrush-current detection is taken from the assigned Transformer side function group.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the Protection function groups

The Transf. neutral point function group is connected with one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the Transf. neutral point function group
- Start of the Circuit-breaker failure protection function, if available in the circuit-breaker function group, through the protection functions of the connected Transf. neutral point function group.

In addition to the general assignment of the Transf. neutral point function group to the Circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the Circuit-breaker interaction Editor in the Transf. neutral point function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Circuit-breaker failure protection function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with Protection communication, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.5 Protection Communication.

Neutral-Point Related Transformer Data

The transformer data characterize the transformer neutral point to be protected. The transformer data applies for all of the functions in the Transf. neutral point function group.

Operational Measured Values

The operational measured values are always available in the Transf. neutral point function group and cannot be deleted.

Table 5-4 Operational Measured Values of the Transformer Neutral Point Function Group

Measured Values		Primary	Secondary	% Referenced to
I	Neutral-point current	A	A	Rated operating current of the primary system
V	Voltage	kV	V	Rated operating voltage of the primary system

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the Transf. neutral point function group are combined phase-selectively and output as group indication.

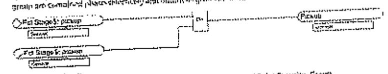

Figure 5-12 Generation of Pickup Indication of the Transf. Neutral Point Function Group

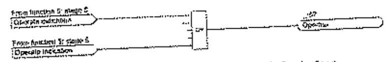

Figure 5-13 Generation of Operate Indication of the Transf. Neutral Point Function Group

5.1.4.3 Application and Setting Notes

Parameter: Rated current (write protected)

- Default setting (_:9421:104) Rated current = 1000 A

The Rated current parameter indicates to you the primary rated current of the transformer to be protected. The Rated current can correspond to the following variables:

- Rated current of the connected transformer side
- Rated current of the reference side of the connected auto transformer

The Rated current cannot be changed.

Parameter: Rated voltage (write protected)

- Default setting (_:9421:105) Rated voltage = 400.00 kV

The Rated voltage parameter indicates to you the primary rated voltage of the transformer to be protected. The Rated voltage can correspond to the following variables:

- Rated voltage of the connected transformer side
- Rated voltage of the reference side of the connected auto transformer

The Rated voltage cannot be changed.

Parameter: Rated Apparent Power

- Default setting (_:9421:103) Rated apparent power = 692.82 MVA

The Rated apparent power parameter indicates to you the calculated value from Rated voltage and Rated current. If current and voltage are available, this value is only displayed for you and cannot be changed.

Parameter: M I-1ph uses MeasP with ID

- Default setting (_:9421:214) M I-1ph uses MeasP with ID = 0

The M I-1ph uses MeasP with ID parameter shows you which 1-phase measuring point is connected to the transformer neutral point. Every measuring point is assigned a unique ID.

Parameter: Scale factor M I-1ph

- Default setting (_:9421:223) Scale factor M I-1ph = 0.000

The parameter Scale factor M I-1ph shows you the magnitude scaling of the transformer neutral-point current.

5.1.4.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:9421:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:9421:104	General:Rated current		1 A to 100 000 A	1000 A
_:9421:105	General:Rated voltage		0.20 kV to 1200.00 kV	400 kV
Side data				
_:9421:214	General:M I-1ph uses measuring point ID		0 to 100	0
_:9421:223	General:Scale factor M I-1ph		0.010 to 100.000	0.000

5.1.4.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:7381:500	Reset LED Group:LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

5.2 Function-Group Type Auto Transformer Differential Protection

5.2.1 Function-Group Types

The following figure shows the structural association of the function-group types.

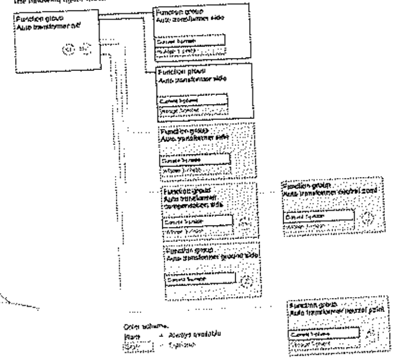

Figure 5-14 Function-Group Types Auto Transformer Diff.

The following function-group types are summarized in the Global DIGSI 5 library:

- Auto transf. diff. (Auto transformer)
- Auto transf. auto side (Auto transformer auto side)
- Auto transf. comp. side (Auto transformer compensation side)
- Auto transf. grd. side (Auto transformer ground side)
- Auto transf. neutral point (Auto transformer neutral point)

The individual function-group types are stored in the Auto Transformer function group folder and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. The Auto transf. diff. function group always contains 2 Auto transf. auto side function groups. The

Auto transf. neutral point function group can be connected if needed with the Auto transf. comp. side or directly with the Auto transf. diff. function group.

The following table shows the number of function group types that can be instantiated depending on the device (7UT82, 7UT85, 7UT86, 7UT87).

NOTE

By purchasing 24 or 120 function points, the 7UT85 and 7UT86 can be expanded to a three-winding transformer or a multi-winding transformer. Consider to provide the respective number of measuring points that are required for the expansion.

Table 5-5 Function-Group Types in the Device

Device	Function-Group Type				
	Auto Transf. Diff.	Auto Transf. Auto Side	Auto Transf. Comp. Side	Auto Transf. Ground Side	Auto Transf. Neutral-Point Function Group
7UT82	Max. 1	Max. 2	–	–	Max. 1
7UT85	Max. 1	Max. 2	Max. 1 (not open)	Max. 1	Max. 1
7UT86	Max. 1	Max. 3 (2 open)	Max. 1	Max. 1	Max. 2
7UT87	Max. 2	Max. 5[5]	Max. 1	Max. 1	Max. 2

In order for the transformer protection to operate properly, switching of the function groups is necessary. Table 5-6 provides an overview of those switching options that are permitted. The Circuit breaker function group is not listed. The images shown in the application templates (see Figure 4-2 to Figure 4-7) give you a good overview of the connection options.

An Auto transf. auto side function group must always be connected to the Auto transf. diff. function group. Depending on the application, a connection of the Auto transf. neutral point function group with the Auto transf. comp. side function group is required. This is the case, for example, if a restricted ground-fault protection is used or if the neutral-point current in the differential protection should be considered (zero-sequence current correction). Conversely, the Auto transf. neutral point function group can also require signals from the Auto transf. diff. function group. A typical case is the inrush-current detection, which can be used for blocking a 1-phase overcurrent protection (with a short time delay set).

Table 5-6 Assignment of Protection Function Groups to Protection Function Groups

Winding	Auto Transf. Diff. 1				Auto Transf. Comp. Side
	Auto Side (2 ... 9)	Comp. Side (0 ... 1)	Ground Side (0 ... 1)	Neutral Point Function Group (0 ... 1)	Neutral Point Function Group (0 ... 1)
Auto transf. auto side 1	X	–	–	–	–
Auto transf. auto side 2	X	–	–	–	–
Auto transformer comp. side	–	X	–	–	–
Auto transformer grd. side	–	–	X	–	–
Auto transf. neutral point 1	–	–	–	X	–
Auto transf. neutral point 2	–	–	–	–	X

The individual function-group types are described in the following.

[5] A maximum of 3 auto sides can be assigned to an auto transformer. The remaining auto sides are available for the 2nd auto transformer.

5.2.2 Function-Group Type Auto Transformer Differential Protection

5.2.2.1 Overview

The Auto transf. Diff. function group contains the differential protection function and protection-related measured values. You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.

You will find the corresponding function groups and also the folders with the usable protection functions in the Global DIGSI library under each device type. You can only load the Differential protection function in the Auto transf. diff. function group.

- Global libraries
  - 7UT85 Transformer, 2 sides
  - 7UT86 Transformer, 3 sides
  - 7UT87 Transformer, up to 5 sides
    - FG Analog Units
    - FG Circuit breaker
    - FG Line
    - FG Motor diff
    - FG Voltage 3ph
    - FG Automatic Voltage control
    - FG Voltage-current 1ph
    - FG Voltage-current 3ph
    - FG Auto transformer diff
      - Auto trf. comp.side
      - Auto trf. ground side
      - Auto trf. nt.point
      - Auto trf. diff.
      - Auto trf. autoside
      - Power-equipment state monitoring
      - Differential protection
      - Gnd flt.prot. for resonant-gnd. / isol.
      - Frequency protection
      - Inrush detect.
      - Power protection
      - Measurements
      - Voltage selection
      - Voltage protection
      - Current protection
      - Temperature Supervision
      - Supervision of secondary system
      - Further protection functions
    - FG Transformer diff

Figure 5-15 Auto Transformer Diff. Function Group – Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, please refer to chapter 4 Applications.

5.2.2.2 Structure of the Function Group

The Auto transf. diff. function group according to Figure 5-16 has interfaces with the Auto transf. auto side and Circuit-breaker function groups. The Auto transf. diff. function group contains the function blocks:

- Protection functions (execution of the differential protection function)
- Trip logic (generation or forwarding of the operate indication)

In order for the protection functionality to be guaranteed, the differential protection function must always be present in the Auto transf. diff. function group. If you do not use an application template, load this from the Global DIGSI 5 library.

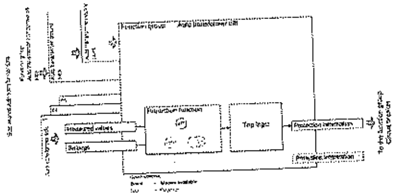

Figure 5-16 Structure of the Auto Transf. Diff. Function Group

The Auto transf. diff. function group has interfaces to the following function groups:

- The Auto transf. auto side function group
- The Auto transf. comp. side function group
- The Auto transf. ground side function group
- The Auto transf. neutral point function group
- Circuit-breaker function group

Interface to the Auto Transformer Auto Side Function Group

The Auto transf. diff. function group receives the required measured values via the interface to the Auto transf. auto side function group. In addition, the required settings are transferred.

By using an application template the Auto transf. diff. function group is connected with the required measuring points.

Interface to the Circuit Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the Circuit-breaker condition in the direction of the Protection function groups

The Auto transf. diff. function group is connected with one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breakers are activated by the protection functions of the Auto transf. diff. function group
- Start of the Circuit-breaker failure protection function, if available in the Circuit-breaker function group, via the protection functions of the connected Auto transf. diff. function group

In addition to the general assignment of the Auto transf. diff. function group to the Circuit-breaker function groups, you can configure the interface in detail for specific functionalities. Configure the details in DIGSI 5 using the Circuit-breaker interaction Editor in the Auto transf. diff. function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Circuit-breaker failure protection function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Interface with Protection Communication (Optional)

All required data is exchanged between the Protection function group and the protection communication via the interface with Protection communication, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.5 Protection Communication.

Auto Transformer Data (Side-Related)

The auto transformer data characterize the auto transformer to be protected. The Auto transf. diff. function group takes these data from the coupled function groups:

- Auto transf. auto side function group
- Auto transf. comp. side function group
- Auto transf. ground side function group
- Auto transf. neutral point function group

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the corresponding indications (group signals) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the Auto transf. diff. function group are combined phase-selectively and output as a group indication.

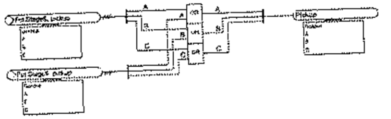

Figure 5-17 Generation of Pickup Indication of the Auto Transformer Diff. Function Group

Figure 5-18 Generation of Operate Indication of the Auto Transformer Diff. Function Group

5.2.2.3 Application and Setting Notes

Parameter: Neutral point

- Default setting (_:91:149) Neutral point = grounded

With the Neutral point parameter, you specify whether the neutral point of the auto transformer is grounded or isolated.

> **NOTE**
>
> The Neutral point parameter is only visible or changeable if you have connected the Auto transformer Diff. function group with the Auto transf. neutral point function group.

5.2.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:91:149	General:Neutral point		• grounded • isolated	grounded

5.2.2.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

5.2.3 Function-Group Type Auto Transformer Auto Side

5.2.3.1 Overview

In the Auto transf. auto side function group all functions required for protection and supervision of an auto transformer auto side can be used. The Auto transf. auto side function group also includes the measurement functions. You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.

The Auto transf. auto side function group must always have a link to the Auto transformer function group. In the Global DIGSI 5 library, you will find the Auto transf. auto side function group under each device type and the folder with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the Auto transf. auto side. The functions are described in chapter 6 Protection and Automation Functions.

- Global libraries
  - 7UT85 Transformer, 2 sides
  - 7UT86 Transformer, 3 sides
  - 7UT87 Transformer, up to 5 sides
    - FG Analog Units
    - FG Circuit breaker
    - FG Line
    - FG Motor diff
    - FG Voltage 3ph
    - FG Automatic Voltage control
    - FG Voltage-current 1ph
    - FG Voltage-current 3ph
    - FG Auto transformer diff
      - Auto trf. comp.side
      - Auto trf. ground side
      - Auto trf. nt.point
      - Auto trf. diff
      - Auto trf. autoside
      - Power-equipment state monitoring
      - Differential protection
      - Gnd flt.prot. for resonant-gnd. / isol.
      - Frequency protection
      - Inrush detect.
      - Power protection
      - Measurements
      - Voltage selection
      - Voltage protection
      - Current protection
      - Temperature Supervision
      - Supervision of secondary system
      - Further protection functions
    - FG Transformer diff

Figure 5-19 Auto Transformer Auto Side Function Group – Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, please refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, please refer to chapter 4 Applications.

5.2.3.2 Structure of the Function Group

The Auto transf. auto side function group always includes the following function blocks:

- Side-dependent auto transformer data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required in the Auto transf. auto side function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the Auto transf. auto side function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

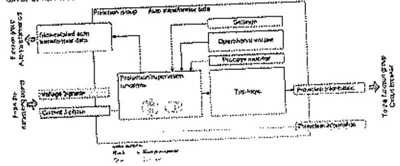

Figure 5-20 Structure of the Auto Transf. Auto Side Function Group

The Auto transf. auto side function group has interfaces to the following function groups:

- Measuring points
- Circuit-breaker function group
- Auto transformer function group

Interfaces with Measuring Points

The Auto transf. auto side function group receives the required measured values via its interfaces with the measuring points.

By using an application template the Auto transf. auto side function group is connected with the required measuring points.

If you insert functions in the Auto transf. auto side function group, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the Function-group connections Editor.

You can find more detailed information in chapter 2 Basic Structure of the Function.

The Auto transf. auto side function group has the following interfaces with the measuring points:

- 3-phase voltage (optional)
  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.
- 3-phase current
  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The Auto transf. auto side function group must always be connected with the Measuring point I-3ph.
  You can connect the 3-phase current interface to a maximum of four 3-phase current measuring points, for example, for 1 1/2 circuit-breaker layouts, two 3-phase current measuring points are required. If 2 current measuring points are connected with the 3-phase current interface, in the Auto transf. auto side function group the total current is additionally formed from the measured values of both measuring points. All functions of the Auto transf. auto side function group have access to these values.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

The Auto transf. auto side function group is connected with one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the Auto transf. auto side function group
- Start of the Circuit-breaker failure protection function, if available in the Circuit-breaker function group, through the protection functions of the connected Auto transf. auto side function group

In addition to the general assignment of the Auto transf. auto side protection function group to the circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the Circuit-breaker interaction editor in the Auto transf. auto side function groups. In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Circuit-breaker failure protection function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 *Function Embedding in the Device*.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with Protection communication, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.5 *Protection Communication*.

Side-Dependent Auto Transformer Data

The auto transformer data characterize the auto transformer auto side to be protected. The side-related auto transformer data applies for all of the functions in the Auto transf. auto side function group.

Process Monitor

The process monitor is always available in the Auto transf. auto side function group and cannot be removed. The process monitor makes the following information available in the Auto transf. auto side function group:

- Current-flow criterion:
  Detection of an open/activated auto transformer auto side based on the flow of leakage current
- Closure detection:
  Recognition of the switching on of the auto transformer auto side
- Cold-load pickup detection (optional)

This information is available in the Auto transf. auto side function group for all the functions included in it. The description of the process monitor begins in chapter 5.11 *Process Monitor*.

Operational Measured Values

The operational measured values are always available in the Auto transf. auto side function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. Only the first 3 lines apply for exclusive current connection.

Table 5-7 Possible Operational Measured Values of the Auto Transformer Auto Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
$3I_0$	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary system √3 · V_{rated} · I_{rated}
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary system √3 · V_{rated} · I_{rated}
S	Apparent power (total power)	MVA	–	Apparent power of the primary system √3 · V_{rated} · I_{rated}
Cos φ	Active factor	(abs)	(abs)	100% corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase V_{rated} · I_{rated}
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase V_{rated} · I_{rated}
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase V_{rated} · I_{rated}

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are both assigned to the stages. The pickup and output logic generate the overreaching indications (group signal) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the Auto transf. auto side function group are combined phase-selectively and output as group indications.

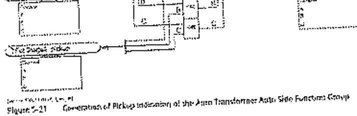

Figure 5-21 Generation of Pickup Indication of the Auto Transformer Auto Side Function Group

Figure 5-22 Generation of Operate Indication of the Auto Transformer Auto Side Function Group

5.2.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

Depending on the protection function used and the circuit breakers to be activated, the connection to the corresponding Circuit breaker must be provided.

You can find more information in chapter 2 *Basic Structure of the Function*.

Parameter: Rated apparent power

- Default setting (_:91:103) Rated apparent power = 692.82 MVA

With the Rated apparent power parameter, you can set the primary rated apparent power for the auto transformer to be protected. The Rated apparent power parameter is relevant for the main protection function of the device. The Rated apparent power set here is the reference value for the percentage-measured values and setting values made in percentages.

> **NOTE**
> If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting (_:91:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you can set the primary rated voltage of the auto transformer to be protected. The Rated voltage parameter is relevant for the main protection function of the device. The Rated voltage set here is the reference value for the percentage-measured values and setting values made in percentages.

> **NOTE**
> If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated Current

- Default setting (_:91:101) Rated current = 1000 A

The Rated current parameter indicates to you the primary rated current of the auto transformer auto side. The Rated current parameter is relevant for the main protection function of the device. The setting value is formed from the Rated voltage and Rated apparent power parameters.

> **NOTE**
> The device also automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the auto transformer to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the auto transformer.

Parameter: Side number

- Default setting (_:91:130) Side number = not assigned

The Side number parameter shows you which auto transformer auto side is currently valid for the following parameters. The side number (Side 1 to Side 5) is automatically assigned with the connection to an auto transformer auto side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting (_:91:210) MI3ph1 usesMeasP with ID = 0

The parameters MI3ph1 usesMeasP with ID to MI3ph4 usesMeasP with ID show you which 3-phase measuring points (MI3ph 1 to MI3ph 4) are connected to the auto transformer auto side. Every measuring point is assigned a unique ID.

Parameter: Scale factor M I-3ph 1

- Default setting (_:91:215) Scale factor M I-3ph 1 = 0.000

The Scale factor M I-3ph 1 parameter shows you the magnitude scaling of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the auto transformer rated current of the side.

Parameter: Scale factor M I-3ph 1 IN

- Default setting (_:91:216) Scale factor M I-3ph 1 IN = 0.000

The Scale factor M I-3ph 1 IN parameter shows you the magnitude scaling of the ground current of the 1st assigned measuring point.

Parameter: Scale factor M I-3ph 2

- Default setting (_:91:217) Scale factor M I-3ph 2 = 0.000

The Scale factor M I-3ph 2 parameter shows you the magnitude scaling of the phase currents of the 2nd assigned measuring point.

Parameter: Scale factor M I-3ph 2 IN

- Default setting (_:91:218) Scale factor M I-3ph 2 IN = 0.000

The Scale factor M I-3ph 2 IN parameter shows you the magnitude scaling of the ground current of the 2nd assigned measuring point.

Parameter: Scale factor M I-3ph 3

- Default setting (_:91:219) Scale factor M I-3ph 3 = 0.000

The Scale factor M I-3ph 3 parameter shows you the magnitude scaling of the phase currents of the 3rd assigned measuring point.

Parameter: Scale factor M I-3ph 3 IN

- Default setting (_:91:220) Scale factor M I-3ph 3 IN = 0.000

The Scale factor M I-3ph 3 IN parameter shows you the magnitude scaling of the ground current of the 3rd assigned measuring point.

Parameter: Scale factor M I-3ph 4

- Default setting (_:91:221) Scale factor M I-3ph 4 = 0.000

The Scale factor M I-3ph 4 parameter shows you the magnitude scaling of the phase currents of the 4th assigned measuring point.

Parameter: Scale factor M I-3ph 4 IN

- Default setting (_:91:222) Scale factor M I-3ph 4 IN = 0.000

The Scale factor M I-3ph 4 IN parameter shows you the magnitude scaling of the ground current of the 4th assigned measuring point.

5.2.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Rated values				
_:91:101	General:Rated current		1 A to 100 000 A	1000 A
Side data				
_:91:130	General:Side number		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:91:210	General:MI3ph 1 uses meas. pt. ID		0 to 100	0
_:91:211	General:MI3ph 2 uses meas. pt. ID		0 to 100	0
_:91:212	General:MI3ph 3 uses meas. pt. ID		0 to 100	0
_:91:213	General:MI3ph 4 uses meas. pt. ID		0 to 100	0
_:91:215	General:Scale factor M I-3ph 1		0.010 to 100.000	0.000

Addr.	Parameters	C	Range of Values	Default Setting
_:91:216	General:Scale factor M I-3ph 1 IN		0.010 to 100.000	0.000
_:91:217	General:Scale factor M I-3ph 2		0.010 to 100.000	0.000
_:91:218	General:Scale factor M I-3ph 2 IN		0.010 to 100.000	0.000
_:91:219	General:Scale factor M I-3ph 3		0.010 to 100.000	0.000
_:91:220	General:Scale factor M I-3ph 3 IN		0.010 to 100.000	0.000
_:91:221	General:Scale factor M I-3ph 4		0.010 to 100.000	0.000
_:91:222	General:Scale factor M I-3ph 4 IN		0.010 to 100.000	0.000

> **NOTE**
> You can find more detailed information on the Process monitor in chapter 5.11 *Process Monitor*.

5.2.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:91:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:91:102	General:Rated voltage		0.40 kV to 800.00 kV	400.00 kV
Measurements				
_:91:158	General:P, Q sign		• not reversed • reversed	not reversed

5.2.3.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_7381:500	Reset LED Group:>LED reset	SPS	I
_7381:320	Reset LED Group:LED have been reset	SPS	O
Closure detec.			
_1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_1131:4681:300	Closure detec.:Closure	SPS	O

5.2.4 Function-Group Type Auto Transformer Compensation Side

5.2.4.1 Overview

In the Auto transf. comp. side all the functions required for protection and supervision of an auto transformer compensation side can be used. The Auto transf. comp. side also includes the measurement functions. You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.

The Auto transf. comp. side must always have a link to the Auto transformer function group.

In the Global DIGSI 5 library you will find the Auto transf. comp. side function group under each device type and the folders with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the Auto transf. comp. side function group. The functions are described in chapter 6 Protection and Automation Functions.

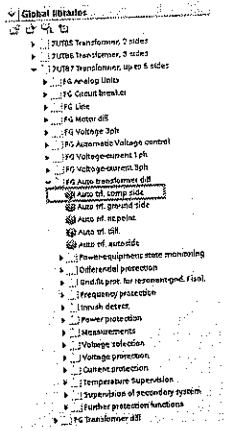

Figure 5-23 Auto Transformer Comp. Side Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, refer to chapter 4 Applications.

5.2.4.2 Structure of the Function Group

The Auto transf. comp. side function group always contains the following function blocks:

- Side-dependent auto transformer data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required for the Auto transf. comp. side function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the Auto transf. comp. side function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

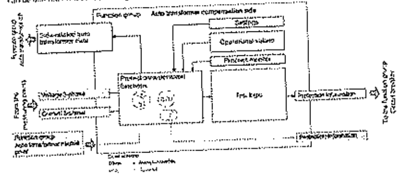

Figure 5-24 Structure of the Auto Transf. Comp. Side Function Group

The Auto transf. comp. side function group has interfaces to the following function groups:

- Measuring points
- Circuit-breaker function group
- Auto transf. diff. function group
- Auto transf. neutral point function group

Interfaces with Measuring Points

The Auto transf. comp. side function group receives the required measured values via its interfaces with the measuring points.

By using an application template the Auto transf. comp. side function group is connected with the required measuring points.

If you insert functions in the Auto transf. comp. side function group, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the Function-group connections Editor.

You can find more detailed information in chapter 2 Basic Structure of the Function.

The Auto transf. comp. side function group has the following interfaces with the measuring points:

- 3-phase voltage (optional):
  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.
- 3-phase current:
  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The Auto transf. comp. side function group must always be linked to the I-3ph measuring point.
  You can connect the 3-phase current interface to a maximum of four 3-phase current measuring points, for example, for 1 1/2 circuit-breaker layouts, two 3-phase current measuring points are required. If 2 current measuring points are connected with the 3-phase current interface, in the Auto transf. comp. side function group the total current is additionally formed from the measured values of both measuring points. All functions of the Auto transf. comp. side function group have access to these values.

> **NOTE**
> The other interfaces can only be connected to one measuring point each!

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

The Auto transf. comp. side function group is connected with one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the Auto transf. comp. side function group.
- Start of the Circuit breaker failure protection function (if available in the Circuit breaker function group) through the protection functions of the connected Auto transf. comp. side function group

In addition to the general assignment of the Auto transf. comp. side function group to the Circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the Circuit-breaker interaction editor in the Auto transf. comp. side function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Circuit-breaker failure protection function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with Protection communication, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.5 Protection Communication.

Side-Dependent Auto Transformer Data

The auto transformer data characterize the auto transformer compensation side to be protected. The auto transformer data applies for all of the functions in the Auto transf. comp. side function group.

Process Monitor

The process monitor is always available in the Auto transf. comp. side function group and cannot be removed. The process monitor makes the following information available in the Auto transf. comp. side function group:

- Current-flow criterion:
  Recognition of an open/closed auto transf. comp. side based on the flowing leakage current
- Closure detection:
  Recognition of the switching on of the auto transf. comp. side
- Cold-load pickup detection (optional).

This information is available in the Auto transf. comp. side function group for all the functions included in it. The description of the process monitor begins in chapter 5.13 Process Monitor.

Operational Measured Values

The operational measured values are always available in the Auto transf. comp. side function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. Only the first 3 lines apply for exclusive current connection.

Table 5-8 Possible Operational Measured Values of the Auto Transformer Comp. Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	-	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	-	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	-	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	-	Active power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	-	Reactive power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$
S_A, S_B, S_C	Phase-related apparent power	MVA	-	Apparent power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the Auto transf. comp. side function group are combined phase-selectively and output as group indication.

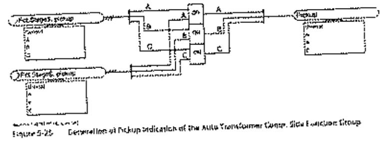

Figure 5-25 Generation of Pickup Indication of the Auto Transformer Comp. Side Function Group

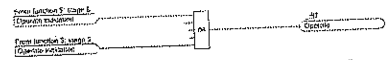

Figure 5-26 Generation of Operate Indication of the Auto Transformer Comp. Side Function Group

5.2.4.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

Depending on the protection function used and the circuit breakers to be activated, the connection to the corresponding Circuit breaker must be provided.

You can find more information in chapter 2 Basic Structure of the Function.

Parameter: Rated apparent power

- Default setting (_:91:103) Rated apparent power = 692.82 MVA

With the Rated apparent power parameter, you can set the primary rated apparent power for the auto transformer to be protected. The Rated apparent power parameter is relevant for the main protection function of the device. The Rated apparent power set here is the reference value for the percentage measured values and setting values made in percentages.

> **NOTE**
> If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting (_:91:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you can set the primary rated voltage of the auto transformer to be protected. The Rated voltage parameter is relevant for the main protection functions of the device. The Rated voltage set here is the reference value for the percentage-measured values and setting values made in percentages.

> **NOTE**
> If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated Current

- Default setting (_:91:101) Rated current = 1000 A

The Rated current parameter indicates to you the primary rated current of the auto transformer. The Rated current parameter is relevant for the main protection function of the device. The setting value is formed from the Rated voltage and Rated apparent power parameters.

Parameter: Neutral point

- Default setting (_:91:149) Neutral point = isolated

With the Neutral point parameter, you specify whether the neutral point is grounded or isolated.

Parameter: Winding configuration

- Default setting (_:91:104) Winding configuration = D (Delta)

With the Winding configuration parameter, you set D (Delta) for a delta connection of the auto transformer. Other setting options are Y (Wye) for a star connection and Z (Zig-Zag) for a zigzag connection. The Winding configuration parameter is relevant for the main protection function.

Parameter: Vector group numeral

- Default setting (_:91:100) Vector group numeral = 3

With the Vector group numeral parameter you set the vector group for the auto transformer to be protected. Each Vector group numeral from 0 to 11 can be set provided it is possible, for example, for Yy, Dd, and Dz, only even and for Yd, Yz, and Dy, only odd numbers are possible. The Vector group numeral parameter is relevant for the main protection function.

> **NOTE**
> The device automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the auto transformer to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the auto transformer.

Parameter: Side number

- Default setting (_:91:130) Side number = not assigned

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The Side number parameter shows you which auto transformer side is currently valid for the following parameters. The side number (Side 1 to Side 5) is automatically assigned with the connection to an auto transformer side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting (_:91:210) MI3ph1 usesMeasP with ID = 0

The parameters MI3ph1 usesMeasP with ID to MI3ph4 usesMeasP with ID show you which 3-phase measuring points (MI3ph 1 to MI3ph 4) are connected to the auto transformer compensation side. Every measuring point is assigned a unique ID.

Parameter: M I-1ph uses MeasP with ID

- Default setting (_:91:214) M I-1ph uses MeasP with ID = 0

The parameter M I-1ph uses MeasP with ID shows you which 1-phase measuring point is connected to the auto transformer compensation side. Every measuring point is assigned a unique ID.

Parameter: Scale factor M I-3ph 1

- Default setting (_:91:215) Scale factor M I-3ph 1 = 0.000

The Scale factor M I-3ph 1 parameter shows you the magnitude scaling of the phase currents of the 1st assigned measuring point. The magnitude value is made up from the ratio of the primary rated current of the current transformer to the auto transformer rated current of the compensation side.

Parameter: Scale factor M I-3ph 1 IN

- Default setting (_:91:216) Scale factor M I-3ph 1 IN = 0.000

The Scale factor M I-3ph 1 IN parameter shows you the magnitude scaling of the ground current of the 1st assigned measuring point.

Parameter: Scale factor M I-3ph 2

- Default setting (_:91:217) Scale factor M I-3ph 2 = 0.000

The Scale factor M I-3ph 2 parameter shows you the magnitude scaling of the phase currents of the 2nd assigned measuring point.

Parameter: Scale factor M I-3ph 2 IN

- Default setting (_:91:218) Scale factor M I-3ph 2 IN = 0.000

The Scale factor M I-3ph 2 IN parameter shows you the magnitude scaling of the ground current of the 2nd assigned measuring point.

Parameter: Scale factor M I-3ph 3

- Default setting (_:91:219) Scale factor M I-3ph 3 = 0.000

The Scale factor M I-3ph 3 parameter shows you the magnitude scaling of the phase currents of the 3rd assigned measuring point.

Parameter: Scale factor M I-3ph 3 IN

- Default setting (_:91:220) Scale factor M I-3ph 3 IN = 0.000

The Scale factor M I-3ph 3 IN parameter shows you the magnitude scaling of the ground current of the 3rd assigned measuring point.

Parameter: Scale factor M I-3ph 4

- Default setting (_:91:221) Scale factor M I-3ph 4 = 0.000

The Scale factor M I-3ph 4 parameter shows you the magnitude scaling of the phase currents of the 4th assigned measuring point.

Parameter: Scale factor M I-3ph 4 IN

- Default setting (_:91:222) Scale factor M I-3ph 4 IN = 0.000

The Scale factor M I-3ph 4 IN parameter shows you the magnitude scaling of the ground current of the 4th assigned measuring point.

Parameter: Scale factor M I-1ph

- Default setting (_:91:223) Scale factor M I-1ph = 0.000

The Scale factor M I-1ph parameter shows you the magnitude scaling of the auto transformer neutral-point current.

5.2.4.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:91:101	General:Rated current		1 A to 100 000 A	1000 A
Side data				
_:91:130	General:Side number		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:91:210	General:MI3ph 1 uses meas. pt. ID		0 to 100	0
_:91:211	General:MI3ph 2 uses meas. pt. ID		0 to 100	0
_:91:212	General:MI3ph 3 uses meas. pt. ID		0 to 100	0
_:91:213	General:MI3ph 4 uses meas. pt. ID		0 to 100	0
_:91:214	General:M I-1ph uses measuring point ID		0 to 100	0
_:91:215	General:Scale factor M I-3ph 1		0.010 to 100.000	0.000
_:91:216	General:Scale factor M I-3ph 1 IN		0.010 to 100.000	0.000
_:91:217	General:Scale factor M I-3ph 2		0.010 to 100.000	0.000
_:91:218	General:Scale factor M I-3ph 2 IN		0.010 to 100.000	0.000
_:91:219	General:Scale factor M I-3ph 3		0.010 to 100.000	0.000
_:91:220	General:Scale factor M I-3ph 3 IN		0.010 to 100.000	0.000
_:91:221	General:Scale factor M I-3ph 4		0.010 to 100.000	0.000

Addr.	Parameter	C	Range of Values	Default Setting
_:91:222	General:Scale factor M I-3ph 4 IN		0.010 to 100.000	0.000
_:91:223	General:Scale factor M I-1ph		0.010 to 100.000	0.000

NOTE

You can find more detailed information on the Process monitor in chapter 5.11 Process Monitor.

5.2.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:91:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:91:102	General:Rated voltage		0.40 kV to 800.00 kV	400.00 kV
Side data				
_:91:149	General:Neutral point		• grounded • isolated	isolated
_:91:104	General:Winding configuration		• Y (Wye) • D (Delta) • Z (Zig-Zag)	D (Delta)
_:91:160	General:Vector group numeral		0 to 11	1
Measurements				
_:91:158	General:P, Q sign		• not reversed • reversed	not reversed

5.2.4.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

5.2.5 Function-Group Type Auto Transformer Ground Side

5.2.5.1 Overview

In the Auto transf. ground side function group all the functions required for protection and supervision of an auto transformer ground side can be used. The Auto transf. ground side function group also includes the

measurement functions. You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.

The Auto transf. ground side function group must always have a link to the Auto transf. function group.

In the Global DIGSI 5 library you will find the Auto transf. ground side function group under each device type and the folders with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the Auto transf. ground side function group. The functions are described in chapter 6 Protection and Automation Functions.

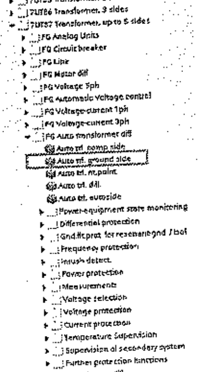

Figure 5-27 Auto Transformer Comp. Ground Side Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to chapter 2 Basic Structure of the Functions. For information about the overall functional scope of the application templates for the various device types, refer to chapter 4 Applications.

5.2.5.2 Structure of the Function Group

The Auto transf. ground side function group always includes the following function blocks:

- Protection and supervision functions
- Auto transformer data
- Operational measured values
- Process monitor
- Output logic of the function group

These blocks are required in the Auto transf. ground side function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the Auto transf. ground side function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

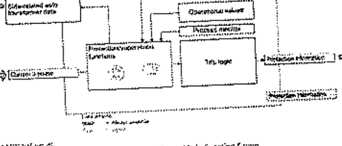

Figure 5-28 Structure of the Auto Transformer Ground Side Function Group

The Auto transf. ground side function group has interfaces to the following function groups:

- Measuring points
- Circuit-breaker function group
- Auto transf. diff. function group

Interfaces with Measuring Points

The Auto transf. ground side function group receives the required measured values via its interfaces with the measuring points.

By using an application template the Auto transf. ground side function group is connected with the required measuring points.

If you insert functions in the Auto transf. ground side function group, they automatically receive the necessary values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the Function-group connections Editor.

You can find more detailed information in chapter 2 Basic Structure of the Function.

The Auto transf. ground side function group has the following interface with the measuring points:

- 3-phase current:
  The measurands from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are for example I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The Auto transf. ground side function group must always be linked to the I-3ph measuring point.
  All functions of the Auto transf. ground side function group have access to these values.

NOTE

You can connect the 3-phase current interface with a maximum of one 3-phase current measuring point.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

The Auto transf. ground side function group is connected with one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the Auto transf. ground side function group
- Start of the Circuit-breaker failure protection function, if available in the Circuit-breaker function group, through the protection functions of the connected Auto transf. ground side function group

In addition to the general assignment of the Auto transf. ground side function group to the circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the Circuit-breaker interaction Editor in the Auto transf. ground side function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Circuit-breaker failure protection function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with Protection communication, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.[illegible] Protection Communication.

Side-Dependent Auto Transformer Data

The auto transformer data characterize the auto transformer ground side to be protected. The auto transformer data applies for all of the functions in the Auto transf. ground side function group.

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Process Monitor

The process monitor is always available in the Auto transf. ground side function group and cannot be removed. The process monitor makes the following information available in the Auto transf. ground side function group:

- Current-flow criterion.
  Recognition of an open/closed auto transf. ground side based on the flowing leakage current.
- Closure detection.
  Recognition of the switching on of the auto transf. ground side
- Cold load pickup detection (optional).

This information is available in the Auto transf. ground side function group for all the functions included in it.
The description of the process monitor begins in chapter 5.11 Process Monitor.

Operational Measured Values

The operational measured values are always available in the Auto transf. ground side function group and cannot be deleted.

Table 5-9 Possible Operational Measured Values of the Auto Transformer Ground Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
f	Frequency	Hz	Hz	Rated frequency

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the Protection Information Interface to the Circuit-breaker function group and are processed further there.

The pickup and trip signals of the protection and supervision functions in the Auto transf. ground side function group are combined phase-selectively and output as group indication.

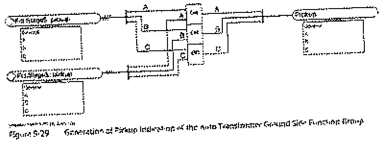

Figure 5-29 Generation of Pickup Indication of the Auto Transformer Ground Side Function Group

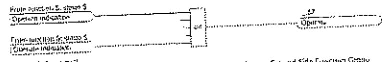

Figure 5-30 Generation of Operate Indication of the Auto Transformer Ground Side Function Group

5.2.5.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

Depending on the protection function used and the circuit breakers to be activated, the connection to the corresponding Circuit breaker must be provided.
You can find more information in chapter 2 Basic Structure of the Function.

Parameter: Rated apparent power

- Default setting (_:91:103) Rated apparent power = 692.82 MVA

With the Rated apparent power parameter, you can set the primary rated apparent power for the auto transformer to be protected. The Rated apparent power parameter is relevant for the main protection function of the device. The Rated apparent power set here is the reference value for the percentage measured values and setting values made in percentages.

> **NOTE**
> If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting (_:91:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you can set the primary rated voltage of the auto transformer to be protected. The Rated voltage parameter is relevant for the main protection function of the device. The Rated voltage set here is the reference value for the percentage measured values and setting values made in percentages.

> **NOTE**
> If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated Current

- Default setting (_:91:101) Rated current = 1000 A

The Rated current parameter indicates to you the primary rated current of the auto transformer side. The Rated current parameter is relevant for the main protection function of the device. The setting value is formed from the Rated voltage and Rated apparent power parameters.

> **NOTE**
> The device automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the auto transformer to be protected and its windings. The currents are converted so that the sensitivity of the protection is based on the rated apparent power of the auto transformer.

Parameter: Side number

- Default setting (_:91:130) Side number = not assigned

The Side number parameter shows you which auto transformer side is currently valid for the following parameters. The side number (Side 1 to Side 5) is automatically assigned with the connection to an auto transformer side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting (_:91:210) MI3ph1 usesMeasP with ID = 0

The parameter MI3ph1 usesMeasP with ID shows you which 3-phase measuring point (MI3ph 1) is connected to the auto transformer side. The measuring point is assigned a unique ID.

Parameter: M I-1ph uses MeasP with ID

- Default setting (_:91:214) M I-1ph uses MeasP with ID = 0

The parameter M I-1ph uses MeasP with ID shows you which 1-phase measuring point is connected to the auto transformer side. Every measuring point is assigned a unique ID.

Parameter: Scale factor M I-3ph 1

- Default setting (_:91:215) Scale factor M I-3ph 1 = 0.000

The Scale factor M I-3ph 1 parameter shows you the magnitude scaling of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the auto transformer rated current of the ground side.

Parameter: Scale factor M I-3ph 1 IN

- Default setting (_:91:216) Scale factor M I-3ph 1 IN = 0.000

The Scale factor M I-3ph 1 IN parameter shows you the magnitude scaling of the ground current of the 1st assigned measuring point.

5.2.5.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Rated values				
_:91:101	General:Rated current		1 A to 100 000 A	1000 A
Side data				
_:91:130	General:Side number		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	Not assigned
_:91:210	General:MI3ph 1 uses meas. pt. ID		0 to 100	0
_:91:215	General:Scale factor M I-3ph 1		0.010 to 100.000	0.000
_:91:216	General:Scale factor M I-3ph 1 IN		0.010 to 100.000	0.000

> **NOTE**
> You can find more detailed information on the Process monitor in chapter 5.11 Process Monitor.

5.2.5.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:91:52	General:Behavior	ENS	O
_:91:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:7381:500	Reset LED Group:LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
Closure detec.			
_:1131:4681:500	Closure detec.:Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

5.2.6 Function-Group Type Auto Transformer Neutral Point

5.2.6.1 Overview

In the Auto transf. neutral point function group all the necessary functions for protection and for supervision of an auto transformer are used, which are related to a neutral-point current. The Auto transf. neutral point also includes the measurement functions. You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.

> **NOTE**
> The transformer and restricted ground fault protection do not work with responsive ground-current transformers. Responsive transformers go to saturation too fast and generate incorrect differential currents.

In the Global DIGSI 5 library you will find the Auto transf. neutral point function group under each device type and the folders with the respective protection functions. Depending on the connected measuring points, you can load the respective protection and supervision functions in the Auto transf. neutral point function group. Here you can only load 1-phase current functions or optional 1-phase voltage functions. The functions are described in chapter 6 Protection and Automation Functions.

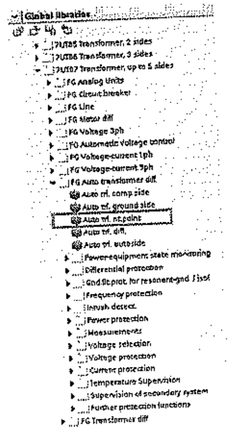

Figure 5-31 Auto Transformer Comp. Neutral Point Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, refer to chapter 4 Applications.

5.2.6.2 Structure of the Function Group

The Auto transf. neutral point function group always includes the following function blocks:

- Neutral point related auto transformer data
- Operational measured values
- Output logic of the function group

These blocks are required in the Auto transf. neutral point function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the Auto transf. neutral point function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

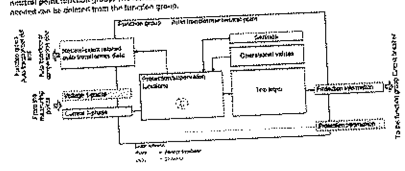

Figure 5-32 Structure of the Auto Transf. Neutral Point Function Group

The Auto transf. neutral point function group has interfaces to the following function groups:

- Measuring points
- Circuit-breaker function group
- Auto transf. diff. function group
- Auto transformer comp. side function group

Interfaces with Measuring Points

The Auto transf. neutral point receives the required measured values via its interfaces with the measuring points.

By using an application template the Auto transf. neutral point function group is connected with the required measuring points.

If you insert functions in the Auto transf. neutral point function group, they automatically receive the measured values of the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the Function-group connections Editor.

You can find more detailed information in chapter 2 Basic Structure of the Function.

The Auto transf. neutral point function group has the following interfaces with the measuring points:

- 1-phase voltage (optional):
  The measurands from the 1-phase voltage system are supplied via this interface. All values that can be calculated from the measurands are also provided via the interface.
  You have to connect the 1-phase voltage interface with the Measuring point V-1ph only if the functions in the Auto transf. neutral point function group work with this measurand.
- 1-phase current
  The measurands from the 1-phase power system are supplied via this interface. Depending on the connection type for the transformers, this is for example I_N. All values that can be calculated from the measurands are also provided via this interface. The Auto transf. neutral point must always be linked with the Measuring point I-1ph.

NOTE

You can connect the 1-phase current interface with a maximum of one 1-phase current measuring point.
All functions of the Auto transf. auto side function group have access to these values.

NOTE

If you instantiate in the Auto transf. neutral point function group, the Overcurrent protection 1ph function, the information for the inrush-current detection is taken from the assigned Auto transf. auto side function group.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit-breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

The Auto transf. neutral point function group is connected with one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breakers are activated by the protection functions of the Auto transf. neutral point function group
- Start of the Circuit-breaker failure protection function, if available in the Circuit-breaker function group, through the protection functions of the connected Auto transf. neutral point function group

In addition to the general assignment of the Auto transf. neutral point function group to the Circuit-breaker function groups, you can configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 using the Circuit-breaker interaction Editor in the Auto transf. neutral point function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Circuit-breaker failure protection function?

If an application template is used, the function groups are connected to each other because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.
You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with Protection communication, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.5 Protection Communication.

Neutral-Point Related Auto Transformer Data

The auto transformer data characterize the auto transformer neutral point to be protected. The auto transformer data applies for all of the functions in the Auto transf. neutral point function group.

Operational Measured Values

The operational measured values are always available in the Auto transf. neutral point function group and cannot be deleted.

Table 5-10 Operational Measured Values of the Auto Transf. Neutral Point Function Group

Measured Values		Primary	Secondary	% Referenced to
I	Neutral-point current	A	A	Rated operating current of the primary system
V	Voltage	kV	V	Rated operating voltage of the primary system

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately, in a pickup logic and an output logic respectively. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the Protection-information interface to the Circuit-breaker function group and are processed further there.
The pickup and trip signals of the protection and supervision functions in the Auto transf. neutral point are combined phase selectively and output as group indication.

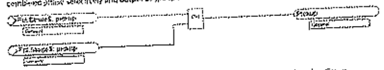

Figure 5-33 Generation of Pickup Indication of the Auto Transf. Neutral Point Function Group

Figure 5-34 Generation of Operate Indication of the Auto Transf. Neutral Point Function Group

5.2.6.3 Application and Setting Notes

Parameter: Rated current

- Default setting (_:9421:101) Rated current = 1000 A

With the Rated current parameter, you can set the primary rated current for the auto transformer to be protected. The Rated current parameter is relevant for the main protection function of the device. The Rated current specified here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

The (_:9421:101) Rated current parameter is not visible with a circuiting of the Auto transformer compensation side or Auto transformer diff. function groups with a Auto transformer auto side function group. Instead the write-protected parameter (_:9421:104) Rated current is displayed.
The (_:9421:102) Rated voltage parameter behaves the same with this circuiting. In its place the (_:9421:105) Rated voltage parameter is displayed.

Parameter: Rated current (write protected)

- Default setting (_:9421:104) Rated current = 1000 A

The Rated current parameter indicates to you the primary rated current of the auto transformer to be protected. The Rated current can correspond to the following variables:

- Rated current of the connected transformer side
- Rated current of the reference side of the connected auto transformer

The Rated current cannot be changed.

Parameter: Rated voltage

- Default setting (_:9421:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you can set the primary rated voltage of the auto transformer to be protected. The Rated voltage parameter is relevant for the main protection function of the device. The Rated voltage set here is the reference value for the percentage measured values and setting values made in percentages.

Parameter: Rated voltage (write protected)

- Default setting (_:9421:105) Rated voltage = 400.00 kV

The Rated voltage parameter indicates to you the primary rated voltage of the auto transformer to be protected. The Rated voltage can correspond to the following variables:

- Rated voltage of the connected transformer side
- Rated voltage of the reference side of the connected auto transformer

The Rated voltage cannot be changed.

Parameter: Rated Apparent Power

- Default setting (_:9421:103) Rated apparent power = 692.82 MVA

The Rated apparent power parameter indicates to you the calculated value from Rated voltage and Rated current. If current and voltage are available, this value is only displayed for you and cannot be changed.

Parameter: M I-1ph uses MeasP with ID

- Default setting (_:9421:214) M I-1ph uses MeasP with ID = 0

The M I-1ph uses MeasP with ID parameter shows you which 1-phase measuring point is connected to the transformer neutral point. Every measuring point is assigned a unique ID.

Parameter: Scale factor M I-1ph

- Default setting (_:9421:223) Scale factor M I-1ph = 0.000

The Scale factor M I-1ph parameter shows you the magnitude scaling of the auto transformer neutral-point current.

5.2.6.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:9421:101	General:Rated current		1 A to 100 000 A	1 000 A
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400 kV

Addr.	Parameter	C	Range of Values	Default Setting
_:9421:103	General:Rated apparent power		0.20 MVA to 5 000.00 MVA	692.82 MVA
_:9421:101	General:Rated current		1 A to 100 000 A	1 000 A
_:9421:105	General:Rated voltage		0.20 kV to 1200.00 kV	400 kV
Side data				
_:9421:214	General:M I-1ph uses measuring point ID		0 to 100	0
_:9421:223	General:Scale factor M I-1ph		0.010 to 100.000	0.000

5.2.6.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

5.3 Overview Function Group Motor Differential Protection

5.3.1 Function-Group Types

In the following graphic, you can see the structured association of the function-group types to the Motor differential protection.

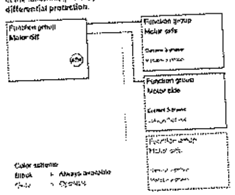

Figure 5-35 Motor Differential Protection Function-Group Types

The following function-group types are summarized in the Global DIGSI 5 library Motor diff.

- Motor Diff.
- Motor Side

The individual function-group types are stored under the Motor diff function group folder and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. The Motor diff. function group always has 2 Motor side function groups. At a maximum, you can assign a total of 3 Motor side function groups to the Motor diff. function group.
The following table shows the number of function-group types that can be instantiated depending on the device (7UT82, 7UT85, 7UT86, 7UT87).

Table 5-11 Function-Group Types in the Device

Device	Function-Group Type: Motor Diff.	Function-Group Type: Motor Side
7UT82	max. 1	max. 2
7UT85	max. 2	max. 4
7UT86	max. 2	max. 5
7UT87	max. 3	max. 7

Interconnection of the function groups is necessary so that the Motor differential protection functions properly. The Circuit-breaker function group is not listed. The figure shown in the application template under in Figure 4-51 offers a good overview of the interconnection options.

Table 5-12 Assignment of Protection Function Groups to Protection Function Groups

	Motor Diff. 1 Side (2 ... 3)
Motor side 1	x
Motor side 2	x

The individual function group types are described in the following.

5.3.2 Function-Group Type Motor Diff

5.3.2.1 Overview

The Motor diff. function group contains the differential protection function and protection function-relevant measured values.
You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.
You will find the corresponding function groups and also the folders with the usable protection functions in the Global DIGSI library under each device type. You can load only the differential protection function in the Motor diff. function group.

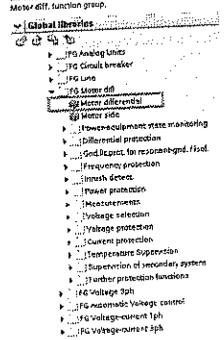

Figure 5-36 Motor Differential Protection Function Group - Functional Scope

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For more information about the embedding of the functions in the device, refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, refer to chapter 4 Applications.

5.3.2.2 Structure of the Function Group

The Motor diff. function group according to 5.3.2.1 Overview has interfaces with the Motor side and Circuit-breaker function groups. The Motor diff. function group contains the function blocks

- Protection function (execution of the differential protection function)
- Trip logic (connection of forwarding of the operate indication)

In the Motor diff. function group, the differential protection function must always be available so that the protection functionality can be ensured. If you do not use an application template, load this from the Global DIGSI 5 library.

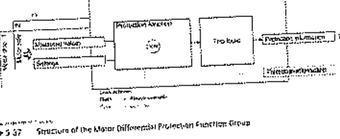

Figure 5-37 Structure of the Motor Differential Protection Function Group

The Motor diff. function group has interfaces to the following components:

- Motor side function group
- Circuit-breaker function group

Interfaces to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

You can connect the Motor diff. function group to one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the Motor diff. function group
- Start of the Circuit-breaker failure protection function, if available in the Circuit-breaker function group, through the protection functions of the connected Motor diff. function group

Besides the general assignment of the Motor diff. function group to the Circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 via the Circuit-breaker interaction Editor in the Motor diff. function group.

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the Circuit-breaker failure protection function

If you are using an application template, the function groups are already connected to each other, because this connection is essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Resetting the LED Group

Using the Reset the LED group function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Interface with Protection Communication (Optional)

All required data is exchanged between the protection function group and the protection communication via the interface with Protection communication. These data are for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.5 Protection Communication.

Motor Data (General)

The motor data characterizes the data of the motor to be protected. The data relevant for the differential protection is shown. The Motor diff. function group takes these data from the coupled function group Motor side function groups.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup and operate indications of the protection and supervision functions in the Motor diff. function group are combined into one group indication using the following numbers and outputs.

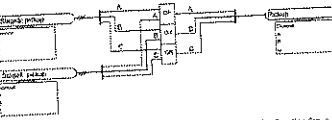

Figure 5-38 Generation of Pickup Indication of the Motor Differential Protection Function Group

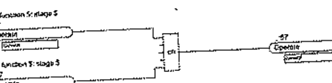

Figure 5-39 Generation of Operate Indication of the Motor Differential Protection Function Group

5.3.2.3 Information

No.	Information	Data class (type)	Type
General			
_:91:52	General: State	ENS	O
_:91:53	General: State	ENS	O
Group indication			
_:4501:55	Group indication: pickup	ACD	O
_:4501:57	Group indication: operate indication	ACT	O
Reset LED FG			
_:7381:506	Reset LED FG: >LED reset	SPS	I
_:7381:329	Reset LED FG: LED reset	SPS	O

5.3.3 Function-Group Type Motor Side

5.3.3.1 Overview

In the Motor side function group, all of the functions that are necessary for protecting and supervising a motor side can be used. The Motor side function group also contains the measuring functions. You can find more information in chapter 9 Measured Values, Energy Values, and Supervision of the Primary System.

The Motor side function group must always have interfacing to the Motor diff. function group.

You will find the corresponding function groups and also the stages with the usable protection functions in the Global DIGSI 5 library under each device type. Depending on the connected measuring points, you can load the respective protection and supervision functions to the Motor side function group. The functions are described in chapter 6 Protection and Automation Functions.

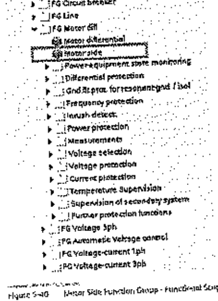

Figure 5-40 Motor Side Function Group - Functional Scope

For more information about the embedding of the functions in the device, refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, refer to chapter 4 Applications.

5.3.3.2 Structure of the Function Group

The Motor side function group always contains the following function blocks:

- Side-dependent motor data
- Operational measured values
- Process monitor
- Trip logic of the function group

These blocks are required for the Motor side function group and therefore cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the Motor side function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

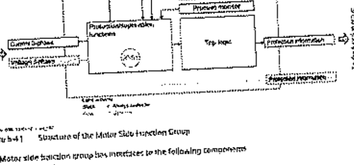

Figure 5-41 Structure of the Motor Side Function Group

The Motor side function group has interfaces to the following components:

- Measuring points
- Motor diff. function group
- Circuit-breaker function group

Interfaces with Measuring Points

The Motor side function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the Motor side function group is already connected to the necessary measuring points.

If you add functions to the Motor side function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the Function-group connections Editor.

You can find more detailed information in chapter 2 Basic Structure of the Function.

The Motor side function group has the following interfaces with the measuring points:

- 3-phase current
  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example: I_A, I_B, I_C, or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The Motor side function group must always be connected to the 3-ph measuring point.
  You can connect the 3-phase current interface to a maximum of four 3-phase current measuring points, for example, for 1 1/2 circuit-breaker layouts. If 3 current measuring points have been connected to the 3-phase current interface, the total current is also determined from measured values from both measuring points in the Motor side function group. All functions in the Motor side function group have access to these values.
- 3-phase voltage (optional)
  The measurands from the 3-phase voltage system are supplied via this interface. Different transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface.
  Connection of the 3-phase voltage interface is optional. This connection is necessary only if protection or supervision functions that require voltage measurements are used.

Interfaces to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the Circuit-breaker function group. The following data is required:

- Pickup and operate indications of the protection functions in the direction of the Circuit breaker function group
- Information on the circuit-breaker condition in the direction of the protection function groups

You can connect the Motor side function group to one or more Circuit-breaker function groups. This connection determines the following:

- Which circuit breakers are activated by the protection functions of the Motor side function group
- Start of the Circuit-breaker failure protection function, if available in the Circuit-breaker function group, through the protection functions of the connected Motor side function group

Besides the general assignment of the Motor side function group to the Circuit-breaker function group, you can also configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 via the Circuit-breaker interaction Editor in the Motor side function group.

In the detail configuration of the interface, you define the following:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the Circuit-breaker failure protection function

If you are using an application template, the function groups are already connected to each other, because this connection is essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor. If the connection is missing, DIGSI 5 reports an inconsistency.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

Interface with Protection Communication (Optional)

All required data is exchanged between the Protection function group and the protection communication via the interface with Protection communication, for example:

- Binary signals
- Measured values
- Complex data

You can find more detailed information in chapter 3.5 Protection Communication.

Resetting the LED Group

Using the Reset the LED group function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Process Monitor

The process monitor is always present in the Motor side function group and cannot be removed. The process monitor provides the following information in the Motor side function group:

- Current-flow criterion:
  Detection of an open/activated motor side based on the flow of leakage current
- Closure detection
  Detection of closure of the motor side
- Cold-load pickup detection (optional)

This information is in the Motor side function group and is available to all the functions in the function group.

The description of the process monitor begins in chapter 5.11 Process Monitor.

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Operational Measured Values

The operational measured values are always present in the Motor side function group and cannot be deleted. If a 3-phase voltage measuring point is connected, the following table shows the total scope. Only the first 3 rows apply for exclusive current connection.

Table 5-3 Possible Operational Measured Values of the Motor Side Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	–	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	–	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	–	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100% corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Active power of the phase $V_{rated\ phs} \cdot I_{rated\ phs}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ phs} \cdot I_{rated\ phs}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ phs} \cdot I_{rated\ phs}$

If a V-3ph measuring point was connected to the Motor side function group, voltage and phase measurements are available.

The energy measurements are not predefined. If necessary, you must load them from the Global DIGSI 5 library.

Depending on the protection and supervision functions used, additional function measurements can be available. The function values are listed in the information list for the relevant protection or supervision function (see chapter 6 Protection and Automation Functions and 8 Supervision Functions).

NOTE

With the P, Q sign parameters in the function block General, the sign of the following measured values of the respective function group can be inverted (see chapter 9.2 Structure of the Function Structure of the Function, written Inversion of Output-Related Measured and Statistical Values):

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase-related): Q_A, Q_B and Q_C

Motor Data (Side-Related)

The motor data characterizes the data of the motor to be protected. The side-dependent motor data applies for all of the functions in the Motor side function group.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions in the function group separately. Pickup logic and output logic are each assigned to the signals. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup and operate indications of the protection and supervision functions in the Motor side function group are combined into one group indication using the following numbers and outputs.

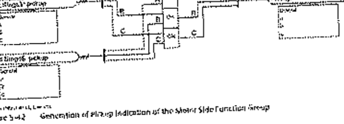

Figure 5-42 Generation of Pickup Indication of the Motor Side Function Group

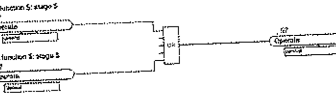

Figure 5-43 Generation of Operate Indication of the Motor Side Function Group

5.3.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

The Motor side function group is usually connected to 1 Circuit-breaker function group. The Circuit-breaker function group is assigned to the circuit breaker of the motor.

Parameter: Rated apparent power

- Default setting (_:1701:14671:103) Rated apparent power = 692.82 MVA

With the Rated apparent power parameter, you can set the primary rated apparent power for the motor to be protected. The Rated apparent power parameter is relevant for the main protection function of the device. The Rated apparent power set here is the reference value for the percentage measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Motor rated voltage

- Default setting (_:1701:14671:102) Motor rated voltage = 400.00 kV

With the Motor rated voltage parameter, you can set the primary rated apparent power for the motor to be protected. The Motor rated voltage parameter is relevant for the main protection function of the device. The Motor rated voltage set here is the reference value for the percentage-measured values and setting values made in percentages.

NOTE

If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Motor rated current

- Default setting (_:1701:14671:101) Motor rated current = 1000 A

The Motor rated current parameter shows you the primary rated current of the motor side. The Motor rated current parameter is relevant for the main protection function of the device. The setting value is formed from the Motor rated voltage and Rated apparent power parameters.

NOTE

The device also automatically calculates the current adaptation formulas required for the winding rated currents from the rated data of the motor to be protected and its windings. This consists are converted so that the sensitivity of the protection is based on the rated apparent power of the motor.

Parameter: Side number

- Default setting (_:1701:14611:130) Side number = not assigned

The Side number parameter shows you which motor side is currently valid for the following settings. The side number (Side 1 to Side 3) is automatically assigned with the connection to a motor side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting (_:1701:14611:210) MI3ph1 usesMeasP with ID = 0

The parameters MI3ph1 usesMeasP with ID to MI3ph4 usesMeasP with ID show you which 3-phase measuring points (MI3ph 1 to MI3ph 4) are connected to the motor side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting (_:1701:14611:215) CT mismatch M I-3ph 1 = 0.000

The CT mismatch M I-3ph 1 parameter shows you the magnitude adaptation of the phase currents of the 1st assigned measuring point. The numerical value is made up from the ratio of the primary rated current of the current transformer to the motor rated current of the side.

Parameter: CT mismatch M I-3ph 1 IN

- Default setting (_:1701:14611:216) CT mismatch M I-3ph 1 IN = 0.000

The CT mismatch M I-3ph 1 IN parameter shows you the magnitude adaptation of the ground current of the 1st assigned measuring point.

Parameter: CT mismatch M I-3ph 2

- Default setting (_:1701:14611:217) CT mismatch M I-3ph 2 = 0.000

The CT mismatch M I-3ph 2 parameter shows you the magnitude adaptation of the phase currents of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 2 IN

- Default setting (_:1701:14611:218) CT mismatch M I-3ph 2 IN = 0.000

The CT mismatch M I-3ph 2 IN parameter shows you the magnitude adaptation of the ground current of the 2nd assigned measuring point.

Parameter: CT mismatch M I-3ph 3

- Default setting (_:1701:14611:219) CT mismatch M I-3ph 3 = 0.000

The CT mismatch M I-3ph 3 parameter shows you the magnitude adaptation of the phase currents of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 3 IN

- Default setting (_:1701:14611:220) CT mismatch M I-3ph 3 IN = 0.000

The CT mismatch M I-3ph 3 IN parameter shows you the magnitude adaptation of the ground current of the 3rd assigned measuring point.

Parameter: CT mismatch M I-3ph 4

- Default setting (_:1701:14611:221) CT mismatch M I-3ph 4 = 0.000

The CT mismatch M I-3ph 4 parameter shows you the magnitude adaptation of the phase currents of the 4th assigned measuring point.

Parameter: CT mismatch M I-3ph 4 IN

- Default setting (_:1701:14611:222) CT mismatch M I-3ph 4 IN = 0.000

The CT mismatch M I-3ph 4 IN parameter shows you the magnitude adaptation of the ground current of the 4th assigned measuring point.

5.3.3.4 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:1701:14671:101	Motor rated current		1 A to 100 000 A	1000 A
Side data				
_:1701:14611:130	Side number		• not assigned • Side 1 • Side 2 • Side 3	not assigned
_:1701:14611:210	MI3ph1 usesMeasP with ID		0 to 100	0
_:1701:14611:211	MI3ph2 usesMeasP with ID		0 to 100	0
_:1701:14611:212	MI3ph3 usesMeasP with ID		0 to 100	0
_:1701:14611:213	MI3ph4 usesMeasP with ID		0 to 100	0
_:1701:14611:215	CT mismatch M I-3ph 1		0.010 to 100.000	0.000
_:1701:14611:216	CT mismatch M I-3ph 1 IN		0.010 to 100.000	0.000
_:1701:14611:217	CT mismatch M I-3ph 2		0.010 to 100.000	0.000
_:1701:14611:218	CT mismatch M I-3ph 2 IN		0.010 to 100.000	0.000
_:1701:14611:219	CT mismatch M I-3ph 3		0.010 to 100.000	0.000
_:1701:14611:220	CT mismatch M I-3ph 3 IN		0.010 to 100.000	0.000
_:1701:14611:221	CT mismatch M I-3ph 4		0.010 to 100.000	0.000
_:1701:14611:222	CT mismatch M I-3ph 4 IN		0.010 to 100.000	0.000

NOTE

You can find more detailed information on the Process monitor in chapter 5.11 Process Monitor.

5.3.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:1701:14671:103	General:Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA
_:1701:14671:102	General:Motor rated voltage		0.40 kV to 800.00 kV	400.00 kV
Measurements				
_:1701:14611:158	Further settings:P, Q sign		• not reversed • reversed	not reversed

5.3.3.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

No.	Information	Data Class (Type)	Type
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

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5.4 Overview Function Groups Generator Differential Protection

5.4.1 Overview

NOTE

This chapter gives you a short overview of the function-group Generator differential protection. You can find descriptions of the 3 listed function-group types and the Generator differential protection function in the generator protection manual (C53000-G5040-C027).

- **Generator Diff** function-group type
- **Generator Side** function-group type
- **Generator Stator** function-group type

The **Generator Diff** function-group type contains the Differential protection function and protection-function-relevant measured values.

Generator-specific protection and supervision functions can operate in the **Generator Side** and **Generator Stator** function-group types. The scope depends on the type of protection concept selected. The **Generator Side** and **Generator Stator** function-group types also contain measuring functions.

You can find the corresponding function groups and the folders with the usable protection functions in the Global DIGSI 5 library under each device type. For example, you can load the Differential protection function in the **Generator Diff** function-group type.

5.5 Function-Group Type Line

5.5.1 Overview

In the Line function group, all of the functions that are necessary for protecting and monitoring a line can be used. The Line function group also contains the measuring functions (for more information, see chapter 9 Measured Values, Energy Values, and Supervision of the Primary System).

You will find the Line function group under each device type in the function library in DIGSI 5. The Line function group contains all of the protection and supervision functions that you can use for this device type. The functions are described in chapter 6 Protection and Automation Functions. The following figure shows the functional scope of the Line function group using the example of a device.

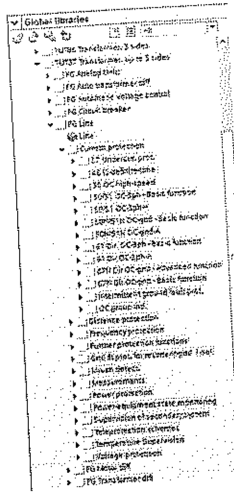

Figure 5-44 Line Function Group - Functional Scope for Device Type 7UT87

For more information about the embedding of the functions in the device, please refer to chapter 2 Basic Structure of the Function. For information about the overall functional scope of the application templates for the various device types, please refer to chapter 4 Applications.

5.5.2 Structure of the Function Group

The Line function group always contains the following blocks:

- Line data
- Operational measurement
- Process monitor
- Output logic of the function group

These blocks are essential for the Line function group, so they cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the Line function group. The functions are available in the function library in DIGSI 5. Functions that are not needed can be deleted from the function group.

The following figure shows the structure of the Line function group:

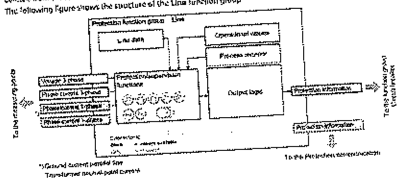

Figure 5-45 Structure of the Line Function Group

The Line function group has interfaces with:

- Measuring points
- Circuit breaker function group
- Protection communication

Interfaces with Measuring Points

The Line function group receives the required measured values via its interfaces with the measuring points.

If you are using an application template, the Line function group is already connected to the necessary measuring points.

If you add functions to the Line function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function-group connections Editor**.

You can find more detailed information in chapter 2 Basic Structure of the Function.

The Line function group has the following interfaces with the measuring points:

- `3-phase voltage`:
  The measurands from the 3-phase voltage system are supplied via this interface. Various transformer connection types are possible. All values that can be calculated from the measurands are also provided via this interface. The Line function group must always be connected to the V-3ph measuring point.
  If you want to use the Distance-protection function in the Line function group for your use case, you must connect the 3 phase-to-ground voltages to the V-3ph measuring point. If you want to test or change the connection between the voltages and the V-3ph measuring point, double-click Measuring point routing (connection type = 3 phase-to-ground voltage) in the DIGSI 5 project tree → 7SL86 (name of the device).
  For more information, please refer to the description of the power-system data starting from chapter 6.1.1 Overview.
- `Phase current 3-phase`
  The measurands from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are for example I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The Line function group must always be connected to the I-3ph measuring point.
  You can connect the `phase current 3-phase` interface to a maximum of two 3-phase current measuring points (for example, for 1 1/2 circuit-breaker layouts). If 2 current measuring points have been connected to the phase current 3-phase interface, the total current is also determined from measured values from both measuring points in the Line function group. All functions in the Line function group have access to these values.
- `Ground current parallel line`:
  If the device measures the ground current in the parallel line, this 1-phase measurand of the Line function group is provided via this interface.
  You only have to connect the `Ground current parallel line` interface to the I-1ph measuring point if functions in the Line function group are working with this measurand.
- `Transformer neutral-point current`:
  If the device measures the ground current in the transformer neutral point, this 1-phase measurand of the Line function group is provided via this interface.
  You only have to connect the `Transformer neutral-point current` interface to the I-1ph measuring point if functions in the Line function group are working with this measurand.

NOTE

You can connect the `3-phase phase current` interface to at most two 3-phase current measuring points (for example, for 1 1/2 circuit-breaker layouts).

The other interfaces can only be connected to one measuring point each!

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit breaker function groups via the interface with the Circuit breaker function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

The Line function group is connected to one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are activated by the protection functions of the Line protection function group
- Start of the Circuit-breaker failure protection function (if available in the circuit-breaker function group) through the protection functions of the connected Line protection function group
- Start of the Automatic reclosing function (AREC, if available in the circuit-breaker function group) through the protection functions of the connected Line protection function group

Besides the general allocation of the Line protection function group to the circuit-breaker function groups, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction Editor** in the Line function group.

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

If you are using an application template, the function groups are already connected to each other, because this connection is essential to ensure proper operation. You can modify the connection in DIGSI 5 via the **Function-group connections Editor**. You can find more detailed information in chapter 2.7 Function Embedding in the Device. If the connection is missing, DIGSI 5 reports an inconsistency.

Interface with Protection Communication

All required data is exchanged between the protection function group and the protection communication via the interface with protection communication. These are, for example, binary signals, measured values and complex data. Functions such as differential protection or teleprotection schemes exchange information with other protection devices via the protection interface.

If an application template is used, the protection function group and protection communication are already connected to each other because this connection is absolutely essential to ensure proper operation.

You can find more detailed information in chapter 3.5 Protection Communication.

If this connection is missing, DIGSI 5 reports an inconsistency.

Line Data

The line data characterizes the line that is to be protected. The line data applies for all of the functions in the Line function group.

Process Monitor

The process monitor is always present in the Line function group and cannot be removed. The process monitor provides the following information in the Line function group:

- Current-flow criterion:
  Detection of an open/closed line based on the flow of minimum current
- Voltage criterion (optional):
  Detection of an open/closed line based on the minimum voltage present
- Closure detection:
  Detection of closure of the line
- Cold-load pickup detection (optional):
  Detection of a transient state of the network after a long period of disconnection (such as a blackout) followed by automatic reclosing

This information is in the Line function group and is available to all the functions in the function group. The description of the process monitor begins in chapter 5.5.4 Process Monitor (FG Line).

Operational Measured Values

The operational measured values are always present in the Line function group and cannot be deleted.

The following table shows the operational measured values of the Line function group:

Table 5-14 Operational Measured Values of the Function Group Line

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system

Measured Values		Primary	Secondary	% Referenced to
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary system
I_N	Neutral-point phase current	A	A	Rated operating current of the primary system
I_{Ns}	Sensitive ground current	A	mA	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary system
V_0	Zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_{NG}	Neutral point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	-	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	-	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	-	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	-	Apparent power of the phase $V_{rated} \cdot I_{rated}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	-	Apparent power of the phase $V_{rated} \cdot I_{rated}$
S_A, S_B, S_C	Phase-related apparent power	MVA	-	Apparent power of the phase $V_{rated} \cdot I_{rated}$

Inversion of Power-Related Measured and Statistical Values (FB General)

The following directional values calculated in operational measured values are defined positively in the direction of the protected object:

- Power
- Power factor
- Energy
- Minimum, maximum values
- Average values

With the P, Q sign setting, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.

More information can be found in chapter 2.1 Overview of Functions.

Output Logic

The output logic treats the pickup and operate indications of the protection and supervision functions in the function group separately, in either a pickup logic or an output logic. The pickup and output logic generate the overreaching indications (group signals) of the function group. These group indications are transferred via the **Protection information interface** to the **Circuit-breaker** function group and are processed further there.

The pickup indications of the protection and supervision functions in the Line function group are combined phase-segregated and output as a group indication.

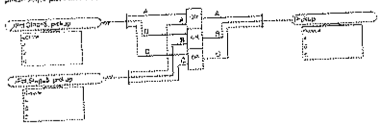

Figure 5-46 Generation of a Pickup Indication of the Line Function Group

The operate indications from the protection functions of the Line function group always result in 3-pole tripping of the device.

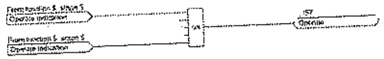

Figure 5-47 Generation of an Operate Indication of the Line Function Group

5.5.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

The Line protection function group is linked to 2 circuit breakers (2 circuit-breaker function groups) for 1 1/2 circuit-breaker layouts.

You can find more information in chapter 2 Basic Structure of the Function.

Line Data

The following application and setting instructions apply for the line data. The line data are configured in the Line function group and apply for all functions in the function group.

> **NOTE**
> Specify the line data for your specific application!

Parameter: Rated current

- Default setting (_:9001:101) Rated current = 1000 A

With the Rated current parameter, you can set the primary rated current for the line to be protected. The Rated current parameter is relevant for the Differential-protection function. The Rated current specified here is the reference value for the percentage-measured values and setting values made in percentages.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated voltage

- Default setting (_:9001:102) Rated voltage = 400 kV

With the Rated voltage parameter, you can set the primary rated voltage for the line to be protected. The Rated voltage parameter is relevant for the Differential-protection, Distance-protection, and Voltage-protection functions. The Rated voltage set here is the reference value for the percentage-measured values and setting values made in percentages.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Neutral point

- Default setting (_:9001:149) Neutral point = grounded

With the Neutral point parameter, you specify whether the system neutral point is grounded, isolated or suppression coil grounded (grounded via arc-suppression coil).

Parameter: C1 per length unit

- Default setting (_:9001:112) C1 per length unit = 0.010 µF/km

With the C1 per length unit parameter, you specify the capacitance per unit length in the positive-sequence system for the line to be protected. You set the C1 per length unit parameter as a relative value in µF/km or µF/miles. The capacitance per unit length in the positive-sequence system is identical to the operating capacitance C_b'. The C1 per length unit parameter is relevant for the Differential and Overvoltage protection with positive-sequence system and compounding functions.

Parameter: C0 per length unit

- Default setting (_:9001:148) C0 per length unit = 0.010 µF/km

With the C0 per length unit parameter, you specify the capacitance per unit length in the zero-sequence system for the line to be protected. You set the C0 per length unit parameter as a relative value in µF/km or µF/miles. The capacitance per unit length in the zero-sequence system is identical to the ground capacitance C_{E}'. The C0 per length unit parameter is relevant for the Differential-protection function.

> **EXAMPLE**
> 110-kV single-conductor liquid-filled cable 3 · 185 mm² Cu with the data:
> $c_b' = c_E' = 0.27$ µF/km
> The setting value for the parameters C1 per length unit and C0 per length unit is 0.27 µF/km.

Parameter: X per length unit

- Default setting (_:9001:113) X per length unit = 0.0525 Ω/km

With the X per length unit parameter you set the reactance per unit length for the line to be protected. You set the X per length unit parameter as a relative value in Ω/km or Ω/miles. The X per length unit parameter is relevant for the Distance-protection, Differential-protection, and Overvoltage protection with positive-sequence system and compounding functions.

Parameter: Line length

- Default setting (_:9001:114) Line length = 60 km

With the Line length parameter, you can set the length of the line to be protected as unit of length in km or miles. The Line length parameter is relevant for the Distance-protection, Differential-protection, and Overvoltage protection with positive-sequence system and compounding functions.

Parameter: Line angle

- Default setting (_:9001:108) Line angle = 85°

The Line angle parameter is relevant for the Distance-protection, Differential-protection, and Overvoltage protection with positive-sequence system and compounding functions. Calculate the setting value for the parameter Line angle from the line constants for the line to be protected as follows:

$$\tan\varphi = \frac{X_L}{R_L} \quad \text{or} \quad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

where:

R_L Resistance of the line to be protected
X_L Reactance of the line to be protected

> **EXAMPLE**
> 110 kV overhead line 150 mm² with the data
> $R'_1 = 0.19$ Ω/km
> $X'_1 = 0.42$ Ω/km
> You calculate the setting value for the line angle as follows:
> $$\tan\varphi = \frac{X_L}{R_L} = \frac{X_1}{R_1} = \frac{0.42\ \Omega/km}{0.19\ \Omega/km} = 2.21$$
> $\arctan(2.21) = 65.7°$

Parameter: Kr and Kx

- Default setting (_:9001:104) Kr = 1.0
- Default setting (_:9001:105) Kx = 1.0

> **NOTE**
> The visibility of the Kr and Kx parameters depends on the selected setting format of the residual compensation factors. The parameters Kr and Kx only become visible after you have set the parameter Set. format residu. comp. = Kr, Kx for the device.

The Kr and Kx parameters are used to set the residual compensation factors as scalar values. The Kr and Kx parameters are relevant for the Distance-protection and Fault-location functions.

> **NOTE**
> You can overwrite the residual compensation factors specified here in the distance protection zones with specific parameters for each zone.

Calculate the setting values for the parameters Kr and Kx from the line data as follows:

Resistance ratio

$$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3}\cdot\left(\frac{R_0}{R_1} - 1\right) \qquad Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3}\cdot\left(\frac{X_0}{X_1} - 1\right)$$

where

R_0 Zero-sequence system resistance of the line
X_0 Zero-sequence system reactance of the line
R_1 Positive-sequence system resistance of the line
X_1 Positive-sequence system reactance of the line

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

> **EXAMPLE**
> 110 kV overhead line 150 mm² with the data:
> R_1/s 0.19 Ω/km positive-sequence system resistance
> X_1/s 0.42 Ω/km positive-sequence system reactance
> R_0/s 0.53 Ω/km zero-sequence system resistance
> X_0/s 1.19 Ω/km zero-sequence system reactance
> s Line length
> You receive the following setting values for the parameters Kr and Kx:
> $$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3}\cdot\left(\frac{R_0}{R_1} - 1\right) = \frac{1}{3}\cdot\left(\frac{0.53\ \Omega/km}{0.19\ \Omega/km} - 1\right) = 0.60$$
> $$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3}\cdot\left(\frac{X_0}{X_1} - 1\right) = \frac{1}{3}\cdot\left(\frac{1.19\ \Omega/km}{0.42\ \Omega/km} - 1\right) = 0.61$$

Parameter: K0 and Angle (K0)

- Default setting (_:9001:118) K0 = 1.000
- Default setting (_:9001:150) Angle (K0) = 0.00°

> **NOTE**
> The visibility of the K0 and Angle (K0) parameters depends on the selected setting format of the residual compensation factors. The parameters K0 and Angle (K0) only become visible after you have set the parameter Set. format residu. comp. = K0 for the device.

The K0 and Angle (K0) parameters are used to set the complex residual compensation factor. The K0 and Angle (K0) parameters are relevant for the Distance-protection and Fault-location functions.

> **NOTE**
> You can overwrite the residual compensation factors specified here in the distance protection zones with zone parameters for each zone.

Make sure that the line angle is set correctly because the device needs the line angle for calculation of the compensation components from the K0 factor. The complex residual compensation factor is defined by the value and the angle. You can calculate the complex residual compensation factor from the line data as follows:

$$\underline{K}_0 = \frac{\underline{Z}_{gnd}}{\underline{Z}_L} = \frac{1}{3}\cdot\left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)$$

where:

$\underline{Z}_0$ (Complex) zero-sequence impedance
$\underline{Z}_1$ (Complex) positive-sequence impedance

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. The data can be calculated both from the primary values and from the secondary values.

For overhead lines, you can use the values for the calculation because the angles of the zero-sequence system and the positive-sequence system differ only slightly. For cables, however, significant angular differences can occur, as the following example illustrates.

> **EXAMPLE**
> 110-kV single-phase liquid-filled cable 3 · 185 mm² Cu with the data:
> Z_1/s 0.408 · $e^{j73°}$ Ω/km positive-sequence impedance
> Z_0/s 0.632 · $e^{j18.4°}$ Ω/km zero-sequence impedance
> s Line length
> The values for calculation of the residual compensation factor K0 are:
> $$\frac{\underline{Z}_0}{\underline{Z}_1} = \frac{0.632}{0.408}\cdot e^{j(18.4°-73°)} = 1.55\cdot e^{-j54.6°} = 1.55\cdot(0.579 - j0.815) = 0.898 - j1.263$$
> $$\underline{K}_0 = \left|\frac{1}{3}\cdot\left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right| = \left|\frac{1}{3}\cdot(0.898 - j1.263 - 1)\right| = \left|\frac{1}{3}\cdot(-0.102 - j1.263)\right|$$
> The setting value of the parameter K0 is calculated from:
> $$K_0 = \left|\frac{1}{3}\cdot\sqrt{(-0.102^2) + (-1.263^2)}\right| = 0.42$$
> When determining the angle, take note of the quadrant of the result. The following table lists the quadrants and the angle range obtained from the operational signs of the real and imaginary parts of K0.
>
> | Real Part | Imaginary Part | tan Phi (K0) | Quadrant/Range | | Calculation Method |
> |---|---|---|---|---|---|
> | + | + | + | I | 0° to 90° | arc tan (|Imag| / |Real|) |
> | + | - | - | IV | -90° to 0° | -arc tan (|Imag| / |Real|) |
> | - | - | + | III | -90° to -180° | arc tan (|Imag| / |Real|) -180° |
> | - | + | - | II | +90° to +180° | -arc tan (|Imag| / |Real|) +180° |
>
> In this example, the following setting value for the Angle (K0) parameter is obtained:
> $$\varphi(K_0) = \arctan\left(\frac{1.263}{0.102}\right) - 180° = -94.6°$$

Parameter: KmR and KmX

- Default setting (_:9001:106) KmR = 0.00

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- Default setting (_:9001:107) Xm0 = 0.00

The Rm0 and Xm0 parameters are used to set the coupling impedance for parallel line compensation. The Rm0 parameter (_:9001:106) is used to set the coupling resistance. The Xm0 parameter (_:9001:107) is used to set the coupling reactance. The Rm0 and Xm0 parameters are only relevant for the Distance-protection function.

Parameter: Km0 and Angle (Km0)

- Default setting (_:9001:124) Km0 = 0.00
- Default setting (_:9001:125) Angle (Km0) = 0.00°

Use the parameters Km0 (= Zm0/3ZL) and Angle (Km0) to set the coupling impedance for parallel line compensation as a complex value in quantity and angle. The Km0 parameter allows you to set the value for the coupling impedance factor. The Angle (Km0) parameter allows you to set the angle of the coupling impedance factor. The Km0 and Angle (Km0) parameters are only relevant for the Distance-protection function.

Parameter: Gnd curr.ratio(MutComp)

- Recommended setting value (_:9001:109) Gnd.curr.ratio(MutComp) = 85 %

The Gnd.curr.ratio(MutComp) parameter is only relevant for the Distance-protection function. With the Gnd.curr.ratio(MutComp) parameter, you define the ground-current balance for parallel-line compensation. This parameter is important for parallel line compensation in the event of ground faults outside of the line to be protected.

For the ground-current balance of the distance protection, the setting value reflects the current ratio I_{E}/I_{EP} for the protection device at installation site B (see Figure 5-48).

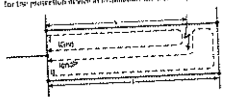

Figure 5-48 Range of Parallel Line Compensation at II

Parallel line compensation is only carried out if the ground current of the line to be protected (I_{E}) is greater than the ground current of the parallel line (I_{EP}) evaluated with the parameter Gnd.curr.ratio(MutComp).

Siemens recommends retaining the default setting Gnd.curr.ratio(MutComp) = 85 %. In highly unbalanced system conditions and if the coupling factor is very small (XM/XL less than 0.4), a smaller value may be advisable.

Parameter: CT saturation detection

- Default setting (_:9001:110) CT saturation detection = no

With the parameter CT saturation detection, you specify whether the device is to work with saturation detection or not. Saturation detection detects measuring errors due to saturation of the current transformers and switches over the method of measurement for distance measurement. The CT saturation detection parameter is only relevant for the Distance-protection function.

Parameter: CT saturation threshold

- Default setting (_:9001:120) CT saturation threshold = 10 A

The CT saturation threshold parameter allows you to set the current threshold for the saturation detection. If the set value is exceeded, saturation detection becomes active. If the saturation detection detects

a CT saturation, the device switches the method of measurement for distance measurement. Calculate the setting value for the parameter CT saturation threshold according to the following rule of thumb:

$$I_{sat} = n \cdot \frac{n'}{5} \cdot I_{rated}$$

where:

$$n' = n \cdot \frac{S_{N} + S_{i}}{S' + S_{i}}$$ Effective overcurrent factor

S_N	Rated burden of the current transformers [VA]
S_i	Inherent burden of the current transformers [VA]
S'	Actually connected burden (protection device + secondary lines)

NOTE

The parameter CT saturation threshold only becomes visible when you have set the parameter CT saturation detection = yes.

Parameter: Series compensation

- Default setting (_:9001:111) Series compensation = no

Use the parameter Series compensation to specify whether the line to be protected is network with or without series compensation. The Series compensation parameter is relevant for the Distance-protection and Directional ground-fault protection functions. To ensure that the direction determination functions correctly in applications for or in the vicinity of series-compensated lines, set the parameter Series compensation = yes.

Parameter: Series capacit. reactance

- Default setting (_:9001:116) Series capacit. reactance = 10 Ω

NOTE

The parameter Series capacit. reactance only becomes visible when you have set the parameter Series compensation = yes.

The Series capacit. reactance parameter is used to define the positive sequence system reactance of the series capacitor. The reactance of the series capacitor is calculated as follows from the capacitance of the capacitor (C_K):

$$X = \frac{1}{2\pi f \cdot C_{K}}$$

The Series capacit. reactance parameter is only relevant for the Directional ground-fault protection function.

Parameter: P, Q sign

- Default setting (_:9001:158) P, Q sign = not reversed

The power and energy values are designed by the manufacturer such that power in the direction of the protected object is considered positive. You can also positively define the power dissipation through the protected object (for example, as seen by the consumer). With the P, Q sign setting, you can invert the sign for these components. This inversion does not influence any protection function.

5.5.4 Process Monitor (FG Line)

5.5.4.1 Overview of Functions

All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor detects the current state of the protected object.

5.5.4.2 Structure of the Function

The Process monitor function is used in the Line protection function group with voltage and current measurement.

The Process monitor function is preconfigured by the manufacturer with the following function blocks:

- Closure detection
- 1-pole-open detector
- Cold-load pickup detection (optional)
- Voltage criterion (optional)
- Circuit breaker condition
- Current-flow criterion

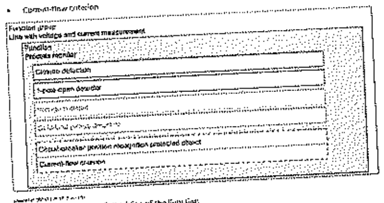

Figure 5-49 Structure/Embedding of the Function

You can switch the voltage criterion and the cold-load pickup detection as necessary. The circuit-breaker position recognition and the current-flow criterion run permanently in the background and are not displayed in DIGSI.

The following figure shows the relationships of the individual function blocks.

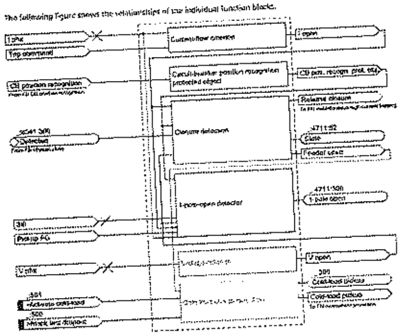

Figure 5-50 Logic Diagram of the Overall Function Process Monitor

5.5.4.3 Current-Flow Criterion

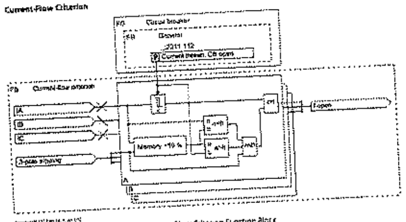

Figure 5-51 Logic Diagram of the Current-Flow Criterion Function Block

The I open signal of one phase is generated if one of the following conditions is met:

- A phase current falls below the set threshold of the Current thresh. CB open parameter. The hysteresis stabilizes the signal.
- The corresponding phase current, for example, I A, falls below 10 % of the phase current when the trip command arrives. If the current does not drop until after a delay due to current transformer influences, an open pole can therefore be detected quickly even after a high-current fault on the line.

With the Current thresh. CB open parameter, you define the minimum current as the criterion for a deactivated line. The parameter lies in the Circuit-breaker function group. It acts both in the Circuit-breaker function group, for example circuit breaker position recognition, and also for the process monitor in the Protection function group.

5.5.4.4 Application and Setting Notes (Current-Flow Criterion)

Parameter: Current thresh. CB open

- Recommended setting value (_:2311:112) Current thresh. CB open = 0.100 A

The Current thresh. CB open parameter is used to define the threshold for the leakage current as the criterion for a deactivated line.

Set the Current thresh. CB open parameter so that the current measured when the feeder is deactivated falls below the value of the Current thresh. CB open parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.

If parasitic currents, for example, due to induction, are ruled out when the feeder is deactivated, set the Current thresh. CB open parameter sensitively.

Siemens recommends a setting value of 0.100 A.

5.5.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

5.5.4.6 Circuit-Breaker Condition for the Protected Object

Logic

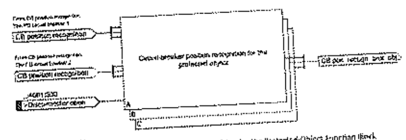

Figure 5-52 Logic Diagram of the Circuit-Breaker Condition for the Protected-Object Function Block

The circuit breaker position recognition in the Circuit breaker (CB) function group provides the circuit breaker condition by way of the internal signal CB pos. recogn. prot. obj..

If a protected object is supplied via 2 circuit breakers (CBs), for example with the 1 1/2 circuit breaker layout, then the circuit-breaker switch position of the protected object must be determined with the aid of both circuit breakers. In this case, the Circuit-breaker position recognition for the protected object function block connects the individual CB states. The connection provides the internal CB pos. recogn. prot. obj. signal to the other function blocks of the process monitor and to other functions, for example, Trip in the event of weak infeed and Echo function for teleprotection method, within the same function group.

If one of the following 2 conditions is met, the CB pos. recogn. prot. obj. signal is in the Open state:

- All connected circuit breakers signal the Open state internally.
- The >Disconnector open input is active.

If the following 2 conditions are met, the CB pos. recogn. prot. obj. signal is in the Closed state:

- At least one of the connected circuit breakers signals the Closed state internally.
- The >Disconnector open input is not active.

5.5.4.7 Closure Detection

Logic

The closure detection enables the immediate tripping of selected protection functions or protection stages when switching to short circuit or the reduction of the responsivity. The closure detection determines whether the protected object is switched on.

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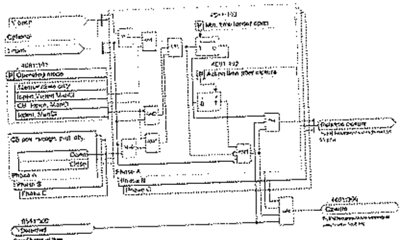

Figure 5-53 Logic Diagram of the Closure-Detection Function Block

For an applied binary input signal Detected (from Manual close function block), the indication Closure is always active. The indication Closure can also be activated via the measurand. In addition the protected object must be switched off for at least the time Min. time feeder open.

This time is started as follows depending on the Operating mode parameter:

- For parameter Operating mode = Iopen, Vopen, ManCl: If the current-flow criterion and the voltage criterion are detected open-circuited.
- For parameter Operating mode = CB, Iopen, ManCl: If the circuit-breaker auxiliary contact(s) or the current flow criterion are detected as open-circuited.
- For parameter Operating mode = Iopen, ManCl: If the current flow criterion is detected as open circuited.

If the protected object is detected as switched off, the phase segregated internal output signal Release (Closure) is formed. The instantaneous high current tripping function can trip immediately, for example with the Release (Closure) signal in the event of connection to a short circuit.

If all the following conditions are active the Closure indication is activated via the measurands

- The protected object is switched off for at least the time Min. time feeder open.
- The time Action time after closure is running.
- The current-flow criterion no longer detects the state open-circuited.

The time Action time after closure is started depending on the Operating mode parameter:

- For parameter Operating mode = Iopen, Vopen, ManCl: If the current-flow criterion or the voltage criterion are no longer detected open-circuited.
- For parameter Operating mode = CB, Iopen, ManCl: If the circuit-breaker auxiliary contact(s) or the current-flow criterion are not detected as open-circuited.
- For parameter Operating mode = Iopen, ManCl: If the current-flow criterion is no longer detected as open-circuited.

5.5.4.8 Application and Setting Notes (Closure Detection)

Parameter: Operating mode

- Default setting (_:4681:101) Operating mode = Manual close only

With the Operating mode parameter, you set the criteria with which the Closure-detection function block operates.

Parameter Value	Description
Manual close only	The detection of feeder closure is exclusively decided using the binary input signal Detected (from Manual close function block). Siemens recommends this setting, if both of the following conditions are met: • The binary input signal Manual On is available on the side of the system. • A closure detection must not happen due to an additional current and voltage measurement, for example, after an automatic reclosing.
Iopen, Vopen, ManCl	The closure detection is done additionally with the current and voltage measurements. If the voltage transformers are installed at the busbar side or if there is no voltage connected, you must not use this setting.
CB, Iopen, ManCl	The closure detection is done additionally with the current measurement and with the evaluation of connected circuit breaker position contacts.
Iopen, ManCl	The closure detection is done additionally with the current measurement. For this setting, make sure that the Current thresh. CB open parameter is set lower than the lowest possible load current. If this is not ensured, open-circuit is detected continuously and each current value that exceeds the Current thresh. CB open parameter is interpreted as closure.

Parameter: Min. time feeder open

- Recommended setting value (_:4681:103) Min. time feeder open = 0.25 s

To avoid incorrect closure detection, the protected object must be switched off for the minimum time of Min. time feeder open before the Closure indication can become active. You define the duration of the release delay with the Min. time feeder open parameter.

Siemens recommends a setting value of 0.25 s.

Parameter: Action time after closure

- Recommended setting value (_:4681:102) Action time after closure = 0.05 s

The Closure indication signals detected closure. With the Action time after closure parameter, you set the Closure indication to a defined length.

Siemens recommends a setting value of 0.05 s.

5.5.4.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Closure detec.				
_:4681:101	Closure detec.:Operating mode		• Manual close only • Iopen,Vopen,ManCl • CB, Iopen, ManCl • Iopen, ManCl	Manual close only
_:4681:102	Closure detec.:Action time after closure		0.01 s to 60.00 s	0.05 s

Addr.	Parameter	C	Setting Options	Default Setting
_:4681:103	Closure detec.:Min. time feeder open		0.05 s to 60.00 s	0.25 s

5.5.4.10 Voltage Criterion (Optional)

Logic

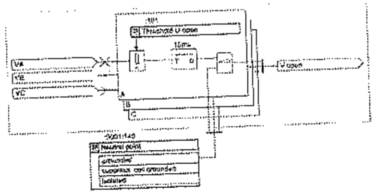

Figure 5-54 Logic Diagram of the Voltage-Criterion Function Block

If you want to test closure detection or an open pole detector via a voltage, you need a voltage transformer installed on the line side and standard power systems with a grounded neutral point. In this case, add the Voltage criterion function block to the process monitor.

If the voltage transformers are installed on the busbar side or if there is no voltage connected, you must not use the voltage criterion to detect a deactivated phase.

With the (_:101) Threshold U open parameter, you define the leakage voltage as the criterion for a deactivated line. If the phase-to-ground voltage falls below the value of the Threshold U open parameter, the U open signal is generated. The function stabilizes the signal with a hysteresis and a delay of the rising edge of the signal. The falling edge of the signal is forwarded without delay.

5.5.4.11 Application and Setting Notes (Voltage Criterion)

Parameter: Threshold U open

> **NOTE**
> The Threshold U open parameter is available only when the optional Voltage criterion function block is used. Use this parameter only with a voltage transformer installed on the line side and in electrical power systems with a grounded neutral point.

- Recommended setting value (_:101) Threshold U open = 30.000 V

With the Threshold U open parameter, you define the threshold for the leakage voltage as the criterion for a deactivated feeder.

Set the Threshold U open parameter so that the voltage measured when the feeder is deactivated falls below the value of the Threshold U open parameter with certainty. The hysteresis is additionally active if the threshold is exceeded. The value of the Threshold U open parameter must be below the minimum expected phase-to-ground voltage. The voltage transformers must be connected on the line side.

Due to possible parasitic voltages (for example, due to capacitive coupling in), do not set the value of the Threshold U open too sensitively.

Siemens recommends a setting value of 30.000 V.

5.5.4.12 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Volt.criterion				
_:101	Volt.criterion:Threshold U open		0.300 V to 170.000 V	30.000 V

5.5.4.13 Cold-Load Pickup Detection (Optional)

Logic

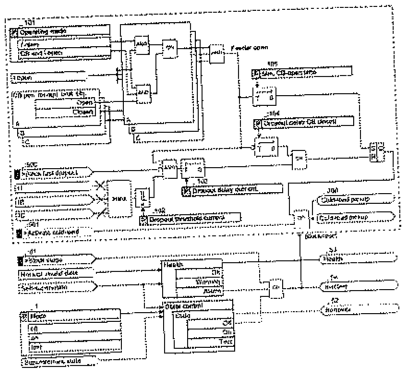

Figure 5-55 Logic Diagram of the Cold-Load Pickup Detection Function Block

The Cold-load pickup detection function block detects that a specific time has been exceeded after deactivation of the line or protected object. If you want to connect the protected object again, you must note that an increased load-current requirement exists for a limited time after connection. This results from the nature of the load.

The Cold-load pickup detection function block ensures that different parameters are used for an adjustable time after connection. For example, for the time of the Min. CB-open time parameter, you can increase the threshold value of a protection function or you can select a special characteristic curve.

If the Cold-load pickup detection function block detects an open feeder and the time of the Min. CB-open time parameter has expired, the indication >Activate cold-load is generated.

With the >Activate cold-load indication, you can activate a parameter set of the Cold-load pickup function. Via the binary input signal >Activate cold-load, you can also activate the >Activate cold-load indication directly.

If the Cold-load pickup detection function block detects closure and the corresponding load current, it starts the time set in the Dropout delay CB closed parameter. The >Activate cold-load indication and the activated parameter set are deactivated after this time has elapsed.

If, for the time set in the Dropout delay curr.crit. parameter, the maximum phase current falls below the threshold value Dropout threshold current, the parameter set for the Cold-load pickup detection function block is also deactivated. As a result, if the load current is very low, the action time Dropout delay curr.crit. of the >Activate cold-load indication can be shortened.

5.5.4.14 Application and Setting Notes (Cold-Load Pickup Detection)

> **NOTE**
> The settings and indications described in this chapter are only available when using the optional Cold-load pickup detection function block.

Parameter: Operating mode

- Default setting (_:101) Operating mode = I open

With the Operating mode parameter, you set the criteria with which the Closure detection function block operates.

Parameter Value	Description
I open	When the Current-flow criterion function block detects a clearing open condition, the decision is made for pickup. For this setting, make sure that the Current thresh. CB open parameter is set lower than the possible load current. If this is not the case, open is detected continuously and each fault current that exceeds the Current thresh. CB open parameter is interpreted as closure.
CB and I open	Closure is detected if one of the following conditions is met: • Analysis of the circuit breaker auxiliary contact detects a clearing open condition in at least one phase. • The current flow criterion detects a clearing open condition.

Parameter: Dropout threshold current

- Default setting (_:102) Dropout threshold current = 1.00 A

With the Dropout threshold current parameter, you set the threshold at which the output signal Cold-load pickup is deactivated when the current in at least one phase falls below this threshold.

Parameter: Dropout delay current criterion

- Default setting (_:103) Dropout delay curr.crit. = 600 s

With the Dropout delay curr.crit. parameter, you set the time for which the actual value must be below the Dropout threshold current threshold so that the output signal Cold-load pickup can be deactivated prematurely.

Parameter: Dropout delay CB closed

- Default setting (_:104) Dropout delay CB closed = 3600 s

With the Dropout delay CB closed parameter, you set the action time for the dynamic parameter set switching in the event of cold-load pickup detection.

Parameter: Min. CB open time

- Default setting (_:105) Min. CB-open time = 3600 s

With the Min. CB-open time parameter, you set the time after which the dynamic parameter set is activated in the event of cold-load pickup when the line is opened.

5.5.4.15 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Cold-load PU				
_:1	Cold-load PU:Mode		• off • on • test	off
_:101	Cold-load PU:Operating mode		• I open • CB and I open	I open
_:102	Cold-load PU:Dropout threshold current	1 A @ 100 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:103	Cold-load PU:Dropout delay curr.crit.		1 s to 600 s	600 s
_:104	Cold-load PU:Dropout delay CB closed		1 s to 21600 s	3600 s
_:105	Cold-load PU:Min. CB open time		0 s to 21600 s	3600 s

5.5.4.16 Information List

No.	Information	Data Class (Type)	Type
Cold-load PU			
_:81	Cold-load PU:>Block stage	SPS	I
_:500	Cold-load PU:>Block fast dropout	SPS	I
_:501	Cold-load PU:>Activate cold-load	SPS	I
_:54	Cold-load PU:Inactive	SPS	O
_:52	Cold-load PU:Behavior	ENS	O
_:53	Cold-load PU:Health	ENS	O
_:300	Cold-load PU:Cold-load pickup	SPS	O

5.6 Function-Group Type Voltage 3-Phase

5.6.1 Overview

In the Voltage 3-phase function group, all functions can be used for protecting and for monitoring a protected object or equipment which allows a 3-phase voltage measurement. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter 9 Measured Values, Energy Values, and Supervision of the Primary System). Applicable functions are, for example, Voltage protection or Frequency protection.

5.6.2 Structure of the Function Group

The Voltage 3-phase function group has interfaces to the measuring points and the Circuit-breaker function group.

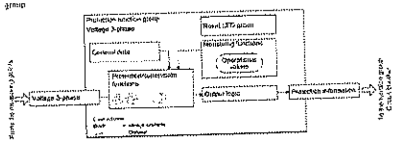

Figure 5-56 Structure of the Voltage 3-Phase Function Group

Interface with Measuring Points

You connect the Voltage 3-phase function group to the voltage measuring points via the interface to the measuring points. This assignment can only be made in DIGSI via Project tree → Function group connections. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

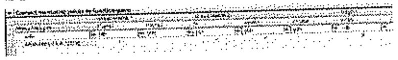

Figure 5-57 Connecting Measuring Points to the Voltage 3-Phase Function Group

If you add functions to the Voltage 3-phase function group, these are connected to the measuring point automatically.

You can connect multiple measuring points with this interface. You can find more information in chapter Voltage Measuring-Point Selection.

The measurands from the 3-phase voltage system are supplied via the V 3-ph interface. Depending on the type of transformer connections, these are, for example, V_A, V_B, V_C, V_{gnd}. All values that can be calculated from the measurands are also provided via this interface.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit-breaker function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit-breaker function group.

You must connect the Voltage 3-phase function group with the Circuit-breaker function group. This assignment can be made in DIGSI only via Project tree → Connect function group. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

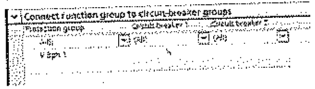

Figure 5-58 Connecting Voltage 3-Phase Function Group with Circuit-Breaker Function Group

Operational Measured Values

The operational measured values are always present in the Voltage 3-phase function group and cannot be deleted.

The following table shows the operational measured values of the Voltage 3-phase function group:

Table 5-15 Operational Measured Values of the Voltage 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency

5.6.3 Application and Setting Notes

NOTE

Before creating the protection functions in the function group, you should first connect these functions to the appropriate Circuit-breaker function group.

Parameter: Rated voltage

- Default setting (_:9421:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you set the primary rated voltage. The Rated voltage set here is the reference value for the percentage-measured values and setting values made in percentages.

5.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV

5.6.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9121:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:4741:500	Reset LED Group:>LED reset	SPS	I
_:4741:320	Reset LED Group:LED have been reset	SPS	O

5.7 Function-Group Type Voltage-Current 1-Phase

5.7.1 Overview

In the Voltage-current 1-phase function group, all functions can be used for protecting and for monitoring a protected object or equipment which allow a 1-phase current and voltage measurement or a zero-sequence voltage measurement via a 3-phase voltage measuring point. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter 9 Measured Values, Energy Values, and Supervision of the Primary System).

5.7.2 Structure of the Function Group

The Voltage-current 1-phase function group has interfaces to the measuring points and the Circuit-breaker function group.

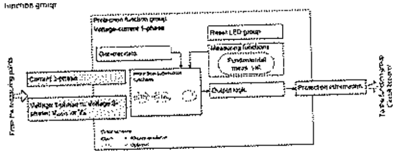

Figure 5-59 Structure of the Voltage-Current 1-Phase Function Group

Interface with Measuring Points

You connect the Voltage-current 1-phase function group to the current and voltage measuring points via the interfaces to the measuring points. At least one measuring point has to be connected. The other is optional. This assignment can only be made in DIGSI via Project tree → Function group connections. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

The function group has the following interfaces to the measuring points:

- 1-phase current

  The 1-phase current measured values are supplied via this interface.

  You can connect multiple measuring points with the 1-phase current interface.

- 1-phase voltage or 3-phase voltage

  You can connect the voltage interface of the function group with a 1-phase or a 3-phase measuring point. The calculated zero-sequence voltage or the measured residual voltage are available for functions with a 3-phase measuring point. The phase-to-ground voltages are not available in the function group Voltage-current 1-phase. You can use both connection types at the same time.

  You configure the 1-phase voltage measuring points via the voltage interface (see the following figure).

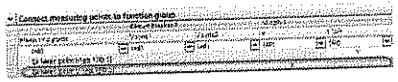

Figure 5-60 Connecting Measuring Points to the Voltage-Current 1-Phase Function Group

The connected, calculated zero-sequence voltage or measured residual voltage from the 3-phase voltage system is available via the voltage interface (see following figure).

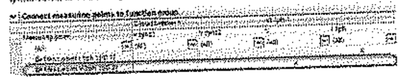

Figure 5-61 Connecting Measuring Points 3-Phase Voltage and 1-Phase Current to the 1-Phase Voltage Current Function Group

You can connect the voltage interface with precisely one 3-phase voltage measuring point. 3 types of 3-phase voltage measuring-point connections are supported. With the different connection types, the type of voltage input also changes in line with the functions. The following table shows the characteristics of the voltage input depending on the types of connection.

Connection Type of the 3-Phase Voltage Measuring Point	Voltage Input
3 ph-to-gnd voltages	The zero-sequence voltage is calculated from the phase-to-ground voltages and used as a voltage input for all functions.
3 ph-to-gnd volt. + VN 3 ph-to-ph volt. + VN	The residual voltage VN is converted to the voltage equivalent of the zero-sequence voltage. The converted voltage is used as a voltage input for functions.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit breaker function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit breaker function group.

You must connect the Voltage-current 1-phase function group with the Circuit-breaker function group. This assignment can only be made in DIGSI via Project tree → Function group connections. To connect the interfaces, set a cross at the intersection between the row and column in the matrix. If the interface is not connected, the functions operate as supervision functions in the Voltage-current 1-phase function group.

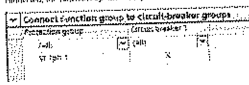

Figure 5-62 Connecting Voltage-Current 1-Phase Function Group with Circuit-Breaker Function Group

Fundamental Components

The fundamental components are always present in the Voltage-current 1-phase function group and cannot be deleted.

The following table shows the fundamental components of the Voltage-current 1-phase function group:

Table 5-16 Fundamental Components of the Voltage-current 1-Phase Function Group

Measured Values		Primary	Secondary	% Referring to
I	1-phase current	A	A	Rated operating current
V[16]	1-phase voltage	kV	V	Rated operating voltage
V_0[17]	Zero-sequence voltage	kV	V	Rated operating voltage/√3
V_N[18]	Residual voltage	kV	V	Rated operating voltage/√3

5.7.3 Write-Protected Settings

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:9421:104	General:Rated apparent power		0.20 MVA to 5000.00 MVA	400.00 MVA
Network data				
_:91:214	General:M I-1ph uses measuring point ID		0 to 100	0
_:91:223	General:Scale factor M I-1ph		0.01 to 100.00	1.00

5.7.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:101	General:Rated current		1 A to 100000 A	1000 A
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:127	General:Number of MeasPoint. 1ph		0 to 11	0

[16] The 1-phase voltage V is only available if it is connected to a 1-phase voltage measuring point.
[17] The zero-sequence voltage V0 is only available if it is connected to a 3-phase voltage measuring point with the 3-phase phase-to-ground voltage connection type.
[18] The residual voltage VN is only available if it is connected to a 3-phase voltage measuring point with the 3-phase phase-to-ground voltage connection type + VN or 3-phase phase-to-phase voltage + VN.

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5.7.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:4421:52	General:Behavior	ENS	O
_:4421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:4741:500	Reset LED Group:>LED reset	SPS	I
_:4741:320	Reset LED Group:LED have been reset	SPS	O

5.8 Function-Group Type Voltage-Current 3-Phase

5.8.1 Overview

All functions for protection and supervision of a protected object or equipment allowing 3-phase voltage and current measurement can be used in the function group Voltage-current 3-phase. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter 9 Measured Values, Energy Values, and Supervision of the Primary System).

You will find the Voltage-current 3-phase function group under each device type in the Global DIGSI 5 library. You will find all protection and supervision functions that you can use for this function-group type in the function group Voltage-current 3-phase. These functions are described in chapter 6 Protection and Automation Functions.

You can find additional information on the embedding of the functions in the device in chapter 2 Basic Structure of the Function. You can find the function scope of the application templates for the various device types in the chapter 4 Applications.

5.8.2 Structure of the Function Group

The function group always contains the following blocks:

- Protected object/equipment data (FB General)
- Operational measured values
- Process monitor
- Output logic of the function group
- Reset LED group

These blocks are essential for the function group under all circumstances, so they cannot be loaded or deleted.

You can load the protection and supervision functions required for your application in the function group. The functions are available in the Global DIGSI 5 library. Functions that are not needed can be deleted from the function group.

The following figure shows the structure of the function group Voltage-current 3-phase.

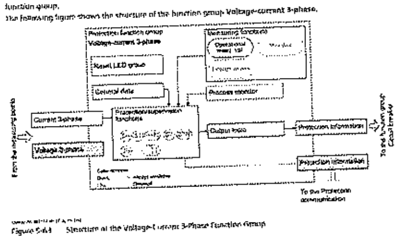

Figure 5-63 Structure of the Voltage-Current 3-Phase Function Group

The function group has interfaces with:

- Measuring points
- Circuit-breaker function groups

Interface with Measuring Points

The function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the function group is already connected to the necessary measuring points. If you add functions to the function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the Function-group connections editor. You can find more detailed information in chapter 2 Basic Structure of the Function.

The function group has the following interfaces with the measuring points:

- 3-phase voltage
  The measurands from the 3-phase voltage system are supplied via this interface. There are various types of transformer connections possible. All values that can be calculated from the measurands are also provided via this interface. The function group must always be linked to the V-3ph measuring point. You can connect multiple measuring points with this interface. You can find more information in chapter 6.54 Voltage Measuring-Point Selection.
  If you want to test or change the connection between the voltages and the V-3ph measuring point, double-click in the DIGSI 5 project tree (Name of the device) on Measuring point routing (Connection type = 3 phase-to-ground voltage). For more information, refer to the description of the power system data starting in chapter 6.1 Power System Data.
- 3-phase current
  The measurands from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are, for example, I_A, I_B, I_C, or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The function group must always be connected to the I-3ph measuring point.
  You can connect the 3-phase current interface to a maximum of four 3-phase current measuring points (for example, for 1 1/2 circuit-breaker layouts). If 2 current measuring points have been connected with the 3-phase current interface, the total current is also determined from measured values. In both measuring points at the function group. All functions in the function group have access to these values.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and Circuit-breaker function groups via the interface with the Circuit-breaker function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

The Voltage-current 3-phase function group is connected to one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are activated by the protection functions of the protection function group
- Starting the Circuit-breaker failure protection function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the Automatic reclosing function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected Protection function group

Besides the general allocation of the protection function group to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the Circuit-breaker interaction editor in the protection function group.

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

If you are using an application template, the function groups are already connected to each other, because this connection is absolutely essential to ensure proper operation. You can modify the connection in DIGSI 5 via the Function-group connections Editor.

You can find more detailed information in chapter 2.7 Function Embedding in the Device.

If the connection is missing, DIGSI 5 reports an inconsistency.

Protected Object/Equipment Data (FB General)

The rated voltage and rated current as well as the neutral-point treatment of the protected object or the equipment are defined here. These data apply to all functions in the Voltage-current 3-phase function group.

Equipment Data

The rated voltage and rated current as well as the neutral point treatment of the object or the equipment are defined here. These data apply to all functions in the Voltage-current 3-phase function group.

Resetting the LED Group

Using the Reset the LED group function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

You can find more detailed information in chapter 3.1.11 Resetting Stored Indications of the Function Group.

Process Monitor

The process monitor is always present in the Voltage-current 3-phase function group and cannot be removed.

The process monitor provides the following information in the Voltage-current 3-phase function group:

- Current-flow criterion:
  Detection of an open/activated protected object/equipment based on the flow of leakage current
- Closure detection:
  Detection of the switching on of the protected object/equipment
- Cold-load pickup detection (optional, only for protection devices):

These data apply to all functions in the Voltage-current 3-phase function group.

The description of the process monitor begins in chapter 5.11 Process Monitor.

Operational Measured Values

The operational measured values are always present in the Voltage-current 3-phase function group and cannot be removed.

The following table shows the operational measured values of the Voltage-current 3-phase function group:

Table 5-17 Operational Measured Values of the Voltage-Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral point phase current	A	A	Rated operating current of the primary values
I_{NS}	Sensitive ground current	A	mA	Rated operating current of the primary values
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency

Measured Values		Primary	Secondary	% Referenced to
P_{total}	Active power (total power)	MW	W	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	W	Active power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	var	Reactive power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$
S_A, S_B, S_C	Phase-related apparent power	MVA	VA	Apparent power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$

The operational measured values are explained in more detail in chapter 9.3 Operational Measured Values.

Inversion of Power-Related Measured and Statistical Values (FB General)

The following directional values calculated in operational measured values are defined positively in the direction of the protected object.

- Power
- Active power factor
- Energy
- Minimum, maximum values
- Average values

With the P, Q sign parameter, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.

More information can be found in chapter 9.1 Overview of Functions.

Output Logic

The output logic treats the pickup and trip signals of the protection and supervision functions that are available in the function group separately, in a pickup logic and a trip logic, respectively. The pickup and trip logic generate the overreaching indications (group indications) of the function group. These group indications are transferred via the Protection information interface to the Circuit-breaker function group and are processed further there.

The pickup signals of the protection and supervision functions in the Voltage-current 3-phase function group are combined in a phase-selective manner and output as a group indication.

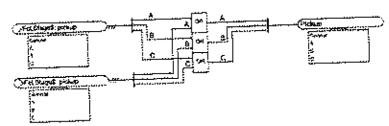

Figure 5-64 Creation of the Pickup Indication of the Voltage-Current 3-Phase Function Group

The trip signals from the protection and supervision functions of the Voltage-current 3-phase function group always result in 3-pole tripping of the device.

Figure 5-65 Creation of the Operate Indication of the Voltage-Current 3-Phase Function Group

5.8.3 Write-Protected Settings

Parameter: Rated apparent power

- Default setting (_:11031) Rated apparent power = 692.82 MVA

With the Rated apparent power parameter, you can set the primary rated apparent power for the transformer to be protected. The Rated apparent power parameter is relevant for the main protection function of the device. The Rated apparent power set here is the reference value for the percentage measured values and setting values made in percentages.

> **NOTE**
>
> If the device works with the IEC 61850 protocol, then you change the setting value of the parameter only via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

The settings listed here are used primarily for understanding during configuration of the function groups. They are calculated on the basis of other settings and cannot be directly changed.

Addr.	Parameters	C	Range of Values	Default Setting
Network data				
_:1103	Gen. calculated apparent power		0.20 MVA to 5 000.00 MVA	692.82 MVA

> **NOTE**
>
> You can find more detailed information on the Process monitor in chapter 5.11 Process Monitor.

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5.8.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9451:101	General:Rated current		1 A to 100 000 A	1 000 A
_:9451:102	General:Rated voltage		0.20 kV to 1 200.00 kV	400.00 kV
Power-system data				
_:9451:149	General:Power-sys. neutral point		• grounded • isolated/res. not grounded • isolated	grounded
Measurements				
_:9451:158	General:P, Q sign		• not reversed • reversed	not reversed

5.8.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9451:52	General:Behavior	ENS	O
_:9451:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

5.9 Function-Group Type Circuit Breaker

5.9.1 Overview

The Circuit-breaker function group combines all the user functions that relate to a circuit breaker.

You will find the Circuit-breaker function group under each device type in the function library in DIGSI 5. The Circuit-breaker function group contains all of the protection, control, and supervision functions that you can use for this device type. The following figure shows, for example, the functional scope of the Circuit-breaker function group.

- FG Circuit breaker
  - Circuit breaker
  - Circuit breaker (status only)
  - Trip-circuit supervision
  - External synchronization
  - Circuit-breaker test
  - Circuit-breaker failure protection
  - CB wear monitoring
  - Voltage selection
  - Control
  - 25 Synchronization
  - 79 Automatic reclosing function

Figure 5-66 Circuit-Breaker Function Group - Example of the Functional Scope

The Circuit-breaker function group includes 2 different types of circuit breakers:

- Circuit breaker
- Circuit breaker (status only)

The circuit-breaker type can accept additional basic function blocks for protection functions along with the actual circuit breaker control.

The circuit breaker (status only) is used only for acquiring the circuit-breaker switch position. This type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

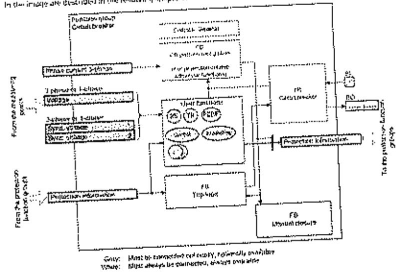
The available functions are described in the chapters 6 Protection and Automation Functions and 7 Control Functions.

5.9.2 Structure of the Function Group

Besides the user functions, the Circuit-breaker function group contains certain functionalities that are essential for general purposes and therefore cannot be loaded or deleted:

- Trip logic
- Mapping the physical circuit breaker
- Circuit-breaker position recognition for protection functions
- Detection of manual closure
- General settings

The following figure shows the structure of the Circuit-breaker function group. The individual function blocks in the image are described in the following chapters.



Gray: Must be connected correctly, optionally available
White: Must always be connected, always available

Figure 5-67 Structure of the Circuit-Breaker Function Group

The Circuit-breaker function group has interfaces with:

- Measuring points
- Protection function groups (for example, the protection function group Transformer or Auto transformer as well as side-related function groups)

Interfaces with Measuring Points

The function group contains the measured values needed from the measuring points associated with this function group.

If an application template is used, the function group is connected to the measuring point of the 3-phase current because this connection is essential. It can be necessary to connect additional measuring points to the function group, depending on the nature of the user functions used. Configuration is carried out using the Function-group connections editor in DIGSI 5. You can find more detailed information on this in chapter 2.1 Function Embedding in the Device.

If a user function, for example, synchronization, is used in the function group but the required measuring point has not linked to it, DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring-point connection.

The Circuit-breaker function group has interfaces with the following measuring points:

- 3-phase line current
  The measurands from the 3-phase power system are supplied via this interface. The function group must always be connected to this measuring point.

- Voltage
  The measurands of the 3-phase voltage system or 1-phase voltage are supplied via this interface. Depending on the connection type of the transformers. In the 3-phase voltage system these are, for example, V_A, V_B, V_C at the line or feeder.
  The connection to the corresponding measuring point is necessary only if a user function that needs the measurand of the 3-phase voltage system is used, for example, to make use of the Synchronization function.
- Sync. Voltage1, Sync. Voltage2
  A 1-phase synchronization voltage (for example, voltage of the busbar with a 1-phase connection) or a 3-phase synchronization voltage (for example, voltage of the busbar with a 3-phase connection) is supplied via this interface.
  The connection to the corresponding measuring point is necessary only if synchronization is used.

Interface with Protection-Function Groups

All required data is exchanged between the Protection and Circuit-breaker function groups via the interface with the Protection function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

If an application template is used, the function groups are connected to each other because this connection is essential to ensure proper operation. You can modify the connection using the Function-group connections editor in DIGSI 5.

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

If the connection is missing, DIGSI 5 reports an inconsistency.

Besides the general assignment of the Protection function group or groups to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail.

- Which operate indications of the protection functions are included when the trip command is generated?
- Which protection functions activate the Automatic reclosing function?
- Which protection functions activate the Circuit-breaker failure protection function?

You can find more detailed information in chapter 2.1 Function Embedding in the Device.

5.9.3 Application and Setting Notes

Interface with Measuring Points

The interface with the 3-phase power system must have been configured. Otherwise, DIGSI 5 signals an inconsistency message.

If the Synchronization function is used, the measuring points that represent voltages V1 and V2 of the parts of the electrical power system to be synchronized must be connected.

You can find more detailed information in the chapter 7.5 Synchronization Function.

Interface with Protection-Function Groups

The Transformer protection-function group is connected to 2 circuit breakers (2 Circuit-breaker function groups) for 1 1/2 circuit-breaker layouts.

Parameter: Rated Normal Current for % Values

- Default setting (_:2311:101) Rated normal current = 1000 A

With the Rated normal current parameter, you set the primary current which serves as a reference for all current-related % values within the Circuit-breaker function group. This applies both for operational measured values and for setting values in %.

Enter the primary rated current of the protected object (for example, the transformer) here.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Rated Voltage for % Values

- Default setting (_:2311:102) Rated voltage = 400 kV

With the Rated voltage parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the Circuit-breaker function group. This applies both for operational measured values and for setting values in %.

Enter the primary rated voltage of the protected object (for example, the line) here.

If the device works with the IEC 61850 protocol, then you change only the setting value of the parameter via DIGSI 5 and not directly on the device. If you change the setting value directly on the device, then the IEC 61850 configuration of the metered values can be faulty.

Parameter: Current Threshold Circuit Breaker Open

- Default setting (_:2311:112) Current thresh. CB open = 0.10 A

With the Current thresh. CB open parameter, you specify the threshold value below which the circuit-breaker pole or the circuit breaker is recognized as open.

Set the Current thresh. CB open parameter so that the current measured when the circuit-breaker pole is open will certainly fall below the parameterized value. If parasitic currents (for example, due to induction) are excluded with the line deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to 0.05 A for example.

If no special requirements exist, Siemens recommends retaining the setting value of 0.10 A for secondary purposes.

5.9.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A	0.030 A to 10.000 A	0.100 A
		5 A	0.150 A to 50.000 A	0.500 A

5.9.5 Information List

No.	Information	Data Class (Type)	Type
Circuit break.			
_:4261:500	Circuit break.:>Ready	SPS	I
_:4261:501	Circuit break.:>Acquisition blocking	SPS	I
_:4261:502	Circuit break.:>Reset switch stat.st.	SPS	I
_:4261:503	Circuit break.:External health	ENS	I
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position 3-pole	DPC	C
_:4261:459	Circuit break.:Position 1-pole phsA	DPC	C
_:4261:460	Circuit break.:Position 1-pole phsB	DPC	C

No.	Information	Data Class (Type)	Type
		DPC	C
_:4261:461	Circuit break.:Position 1-pole phsC	SPS	O
_:4261:300	Circuit break.:Trip/open cmd. 3-pole	SPS	O
_:4261:401	Circuit break.:Trip only pole A	SPS	O
_:4261:402	Circuit break.:Trip only pole B	SPS	O
_:4261:403	Circuit break.:Trip only pole C	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O
_:4261:304	Circuit break.:Alarm suppression	INS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:407	Circuit break.:Op.ct. A	INS	O
_:4261:408	Circuit break.:Op.ct. B	INS	O
_:4261:409	Circuit break.:Op.ct. C	BCR	O
_:4261:307	Circuit break.:ΣI Brk.	BCR	O
_:4261:308	Circuit break.:ΣIA Brk.	BCR	O
_:4261:309	Circuit break.:ΣIB Brk.	BCR	O
_:4261:310	Circuit break.:ΣIC Brk.	MV	O
_:4261:311	Circuit break.:Break.-current phs A	MV	O
_:4261:312	Circuit break.:Break.-current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:314	Circuit break.:Break. voltage phs A	MV	O
_:4261:315	Circuit break.:Break. voltage phs B	MV	O
_:4261:316	Circuit break.:Break. voltage phs C		

5.9.6 Trip Logic

5.9.6.1 Function Description

The Trip logic function block receives the group operate indication from the Protection function group or Protection function groups and forms the protection trip command that is transmitted to the Circuit-breaker function block.

The Circuit-breaker function block activates the device contact and thus causes the circuit breaker to open (see 5.9.7 Circuit Breaker). The command output time is also effective here.

The trip logic also decides when the protection trip command is reset (see Figure 5-69).

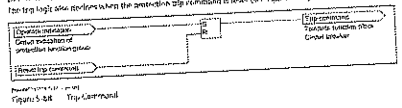


Figure 5-68 Trip Command

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Trip-Command Reset

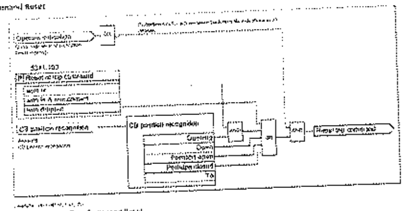

Figure 5-69 Trip-Command Reset

Once a trip command is issued, it is stored (see Figure 5-68).
You determine the criteria for resetting a trip command that has been issued with the parameter Reset of trip command.

- with dropout
  The trip command is reset if the function that initiated tripping resets its operate indication. This occurs typically with dropout. Command reset of the trip command takes place regardless of verification of the circuit-breaker condition.
- with I<
- with I< & aux.contact
  In these criteria, the state of the circuit breaker is also taken into account as a further criterion in addition to the dropout of the tripping function (operate indication is reset by command). You can select whether the state is determined by means of the current (with I<) or by means of the current in conjunction with the circuit breaker auxiliary contacts (with I< & aux.contact). The behavior of these setting options only differs in one situation of the circuit-breaker state. If the circuit breaker is in the opening state, the trip command is reset in the case of the option with I<, whereas it is not reset yet in the case of the option with with I< & aux.contact. The opening state is detected if the auxiliary contacts still detect the circuit breaker as being closed and opening is detected via the decreasing current flow.
  As long as the circuit breaker is detected unambiguously as closed (fully closed), the trip command will not be reset with these setting options.
  The information about the condition of the circuit breaker is supplied by the Circuit-breaker position recognition function block (see 5.9.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions). The determination of the various conditions is also described in this chapter.

5.9.6.2 Application and Setting Notes

Parameter: Reset of trip command

- Recommended setting value (_:5311:103) Reset of trip command = with I<

Parameter Value	Description
with I<	With this setting, the trip command is reset as soon as the current is removed, provided the tripping function has dropped out. The most important factor for recognition of the open circuit breaker is the current falling short of the value set at the parameter (_:2311:112) Current thresh. CB open.
with I< & aux.contact	For this setting not only the current has to be removed, but also the circuit-breaker auxiliary contact has to report that the circuit breaker is open. This setting assumes that the setting of the auxiliary contact has been routed via a binary input (for more information, see 5.9.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information).
with dropout	The setting can be selected for special applications in which the trip command does not result in complete interruption of the current in every case. In this case, the trip command is reset if the pickup of the tripping protection function drops out. The setting is useful if the load current in the system cannot be interrupted during the protection device test and the test current is fed in parallel with the load current.

5.9.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<

5.9.6.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O

5.9.7 Circuit Breaker

5.9.7.1 Overview

The Circuit-breaker function block represents the physical switch in the SIPROTEC 5 device.
The basic tasks of this function block are the operation of the circuit breaker and the acquisition of the circuit-breaker auxiliary contacts and other circuit-breaker information.
The Circuit-breaker function block provides information about:

- Number of switching cycles
- Breaking current, breaking voltage, and breaking frequency
- Summation breaking current

5.9.7.2 Tripping, Opening, and Closing the Circuit Breaker

The circuit breaker is operated in the following situations:

- Tripping of the circuit breaker as a result of a protection trip command
- Opening of the circuit breaker as a result of control operations
- Closing of the circuit breaker as a result of automatic reclosing or control operations

Tripping is always the result of a protection function. The operate indications of the individual protection functions are summarized at the Trip logic function block. The trip command that causes the tripping in the Circuit breaker function block is generated there.
To operate the circuit breaker, the Circuit-breaker function block provides the output signals that must be routed to the corresponding binary outputs of the device (see Table 5-18).

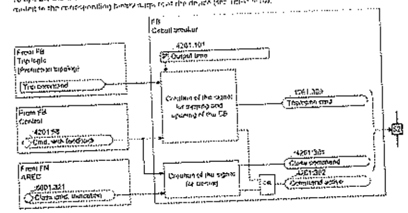

Figure 5-70 Tripping, Opening, and Closing the Circuit Breaker

Table 5-18 Description of the Output Signals

Signal	Description	Routing Options
Trip/open cmd.	This signal executes all tripping and opening operations. The Output time parameter affects the signal. The signal is pending for the duration of this period, with the following exceptions: • Only when switched off by the control: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is open before expiration of the period. • Only in the event of protection tripping: The signal remains active as long as the trip command is still active after expiration of the period (see also 5.9.6.1 Function Description). • Only in the event of protection tripping: With the setting option Only saved in the event of tripping, the signal remains pending until it is acknowledged manually. This only applies for protection tripping.	• Unlatched • Only saved in the event of protection tripping (not when opened)
Close command	This signal executes all closing operations. The Output time parameter affects the signal. The signal is pending for the duration of this period, with the following exception: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is closed before expiration of the period.	Normal routing
Command active	This signal is active as long as one of the binary outputs assigned to the signals Trip/open cmd. and Close command is active because a switching command is being executed by the control.	Normal routing

5.9.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit breaker position, the Circuit breaker function block provides position signals (see next figure).
These signals are of the Double point indication (DPC) type. A double-point indication can be routed to 2 binary inputs so that the open and closed circuit-breaker positions can be reliably acquired.

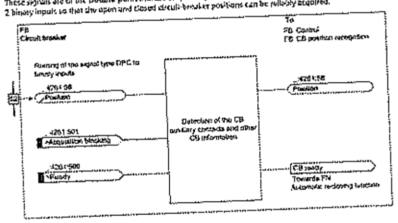

Figure 5-71 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
Position	DPC	Acquisition of the circuit-breaker position The position 3-pole circuit breaker open and/or the position 3-pole circuit breaker closed can be acquired by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is connected with the CB auxiliary contacts. The open and closed signals do not necessarily have to be routed in parallel. The advantage of parallel routing is that it can be used to determine an intermediate or disturbed position. On the other hand, this is not possible if only one signal is routed.
In the monitoring direction, the position signals generate the following information when the open and closed positions are acquired (see following table). This information is further processed by the Circuit-breaker position recognition and Control function blocks.

Information	Type	Description
Off	SPS	Circuit-breaker position is opened.
On	SPS	Circuit-breaker position is closed.
Intermediate position	SPS	Circuit-breaker position is in intermediate position.
Disturbed position	SPS	Circuit-breaker position is in disturbed position.
Not selected	SPS	The circuit breaker is not selected for a control operation.

Other input signals are:

Signal	Type	Description
>Acquisition blocking	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see Other Functions 7.8.1 Function Description for a description of acquisition blocking).

Signal	Type	Description
>Reset AcqBlk&Subst	SPS	This is used to reset acquisition blocking and manual update of the circuit breaker. Setting acquisition blocking and tracking is blocked with the input activated.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an OFF-ON-OFF cycle. The signal remains active as long as the circuit breaker is capable to trip. The signal is used in the Automatic reclosing and Circuit-breaker test functions.

Another output signal is:

External health	SPS	This can be used to indicate the health of the physical circuit breaker. For this, you must acquire any failure information for the circuit breaker via a binary input. This failure information can set the appropriate state of the External health signal with a CFC chart (using the BUILD_ENS block). The signal has no effect on the health of the function block.

5.9.7.4 Circuit-Breaker Tripping Alarm Suppression

Circuit-Breaker Tripping Alarm Suppression

In certain systems, the user may wish to activate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not be issued if the circuit breaker is to be reclosed automatically after tripping or if it is to be closed or opened via the control. The alarm is only to be issued in the event of final tripping.
Depending on how the alarm is generated (for example, triggered by a fleeting contact of the circuit breaker), the Alarm suppression signal can be used to suppress the alarm.
The signal is generated if:

- A definitive protection tripping is not present
- The automatic reclosing function executes a closure
- The integrated control executes a closure or opening action
- External closing is detected via the Manual close function

For further information about its use, please refer to 5.9.8.2 Application and Setting Notes .

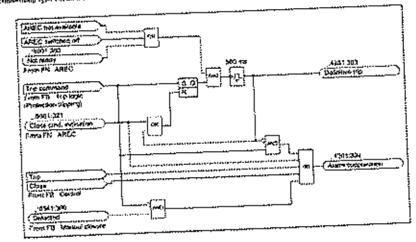

Figure 5-72 Definitive Tripping, Circuit-Breaker Tripping Alarm Suppression

5.9.7.5 Tripping and Opening Information

When a trip command is issued, the tripping information shown in the next figure is saved in the fault log.

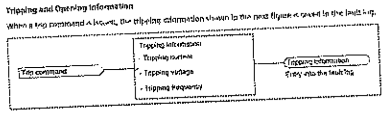

Figure 5-73 Tripping Information

The following statistics information is saved for the circuit breaker:

- Number of switching cycles
  All tripping, opening, and closing operations are counted.
- Number of closing operations by the automatic reclosing function
- Total of tripping and breaking currents

The statistics information can be individually set and reset via the device control. It is also possible to reset all values via the binary input signal >Reset switch [illegible] statist.

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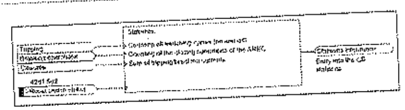

Figure 5-74 Statistics Information About the Circuit Breaker

5.9.7.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

The following image shows the routings needed:

- The device can execute 3-pole tripping (via the protection device).
- The device can execute 3-pole opening (via the control).

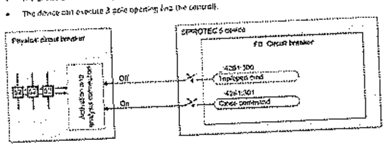

Figure 5-75 Activation of the Circuit Breaker

By routing the Trip/open cmd. signals to 1 or 2 binary outputs, you can carry out 1, 1.5, and 2-pole activations of the circuit breaker. You will find a detailed description of this in 7.5.3.1 Connection Variants of the Circuit Breaker.

NOTE

Do not confuse these 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker with 1-pole or 3-pole tripping of the circuit breaker.

Routing for Analysis of the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. These are for example:

- **Circuit-breaker position recognition function block**
- **Circuit-breaker failure protection function**
- **Control function block**

The operating principle of the auxiliary contacts is described in the individual functions.

Siemens recommends capturing the `Circuit breaker is open in 3 poles` and `Circuit breaker is closed in 3 poles` information via auxiliary contacts. This is the optimal configuration, for the control functionality. For purely protection applications, it is also enough to capture just one of the 2 circuit-breaker positions.

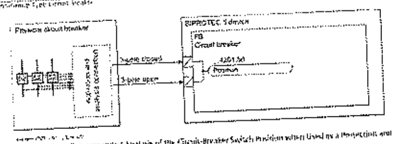

Figure 5-76 Recommended Analysis of the Circuit-Breaker Switch Position when Used as a Protection and Control Device

The following diagram shows the recommended routing, in which H stands for active with voltage.

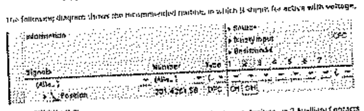

Figure 5-77 Routing for Acquisition of the Circuit-Breaker Switch Position via 2 Auxiliary Contacts

The device can also function without the analysis from the circuit-breaker auxiliary contacts, that is, routing of the auxiliary contacts is not absolutely necessary. However, this is a requirement for control functions.

Parameter: Output time

- Default setting (_:101) `Output time` = 0.10 s

The `Output time` parameter acts on the signals for tripping, opening, and closing of the circuit breaker.

CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

→ Set a time that is long enough to ensure that the circuit breaker reliably reaches its final position (open or closed) after a control operation.

Output Signal: Indication Suppression

Whereas in the case of feeders without an automatic reclosing function every trip command is final due to a protection function, the use of an automatic reclosing function should only cause the motion detector of the circuit breaker (fleeting contact on the circuit breaker) to trigger an alarm if tripping of the circuit breaker is definitive (see next figure for more details). Likewise, a tripping alarm should not be triggered for switching operations by the control.

For this, the alarm activation circuit should be looped via a suitably routed output contact of the device (output signal `Alarm suppression`). In the idle state and when the device is switched off, this contact is permanently closed. For this, an output contact with a break contact must be routed. The contact opens whenever the output signal `Alarm suppression` becomes active, so that tripping or a switching operation

does not cause an alarm (see the logic in 5.9.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information for more details).

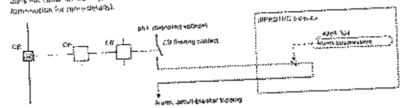

Figure 5-78 Circuit-Breaker Tripping Alarm Suppression

5.9.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Circuit break.				
_:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s

5.9.7.8 Information List

No.	Information	Data Class (Type)	Type
Circuit break.			
_:500	Circuit break.:>Ready	SPS	I
_:501	Circuit break.:>Acquisition blocking	SPS	I
_:502	Circuit break.:>Reset switch statist.	SPS	I
_:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:503	Circuit break.:External health	ENS	I
_:53	Circuit break.:Health	ENS	O
_:58	Circuit break.:Position	DPC	C
_:300	Circuit break.:Trip/open cmd.	SPS	O
_:301	Circuit break.:Close command	SPS	O
_:302	Circuit break.:Command active	SPS	O
_:303	Circuit break.:Definitive trip	SPS	O
_:304	Circuit break.:Alarm suppression	SPS	O
_:306	Circuit break.:Op.ct.	INS	O
_:307	Circuit break.:ΣI Brk.	BCR	O
_:308	Circuit break.:ΣIA Brk.	BCR	O
_:309	Circuit break.:ΣIB Brk.	BCR	O
_:310	Circuit break.:ΣIC Brk.	BCR	O
_:311	Circuit break.:Break.-current phs A	MV	O
_:312	Circuit break.:Break.-current phs B	MV	O
_:313	Circuit break.:Break.-current phs C	MV	O
_:314	Circuit break.:Break. voltage phs A	MV	O
_:315	Circuit break.:Break. voltage phs B	MV	O
_:316	Circuit break.:Break. voltage phs C	MV	O
_:322	Circuit break.:CB open hours	INS	O
_:323	Circuit break.:Operating hours	INS	O

5.9.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.9.8.1 Overview

This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts and the current flow.

This information is needed in the following protection-related additional functions:

- Trip logic (see 5.9.6.1 Function Description)
- Detection of manual closing (see 5.9.9.1 Function Description)
- Process monitor (see Process Monitor (Line Function group) 5.3.4 Process Monitor (FG Line) or Process monitor (Standard VI) 5.12 Process Monitor)

Its use is described in the respective chapters.

The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.

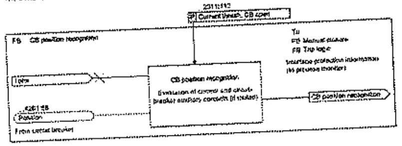

Figure 5-79 Overview of the Circuit-Breaker Condition Position Function

Based on the link between the information from the auxiliary contacts and the current flow, the circuit breaker can assume the following positions:

Circuit-Breaker Condition	Description
Open	The circuit-breaker pole is detected unambiguously as open according to both criteria.
Closed	The circuit-breaker pole is detected unambiguously as closed according to both criteria.
Possibly open, possibly closed	These conditions can occur if the information is incomplete due to the routing of the auxiliary contacts and the condition can no longer be determined reliably. These uncertain conditions are evaluated differently by certain functions.
Opening	This is a dynamically occurring condition that results when, while a trip command is active and the auxiliary contact is still closed, the current is detected to have fallen below the threshold value because the current-flow criterion takes effect faster than the auxiliary contact can open.

5.9.9 Detection Manual Closure (for AREC and Process Monitor)

5.9.9.1 Function Description

Detection of Manual Closure (for Process Monitor)

The **Manual closure** function block detects any closure carried out by hand. This information is used in the **Process monitor** functions (within protection function groups).

The following figure shows the logic for manual closure detection.

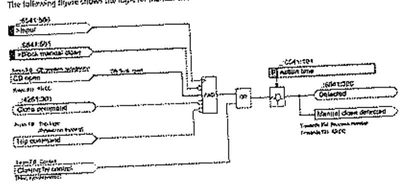

Figure 5-80 Logic for Manual Closure Detection

External Manual Closure

An external manual closure is communicated to the device via the input signal >Input. The input signal can also be connected directly to the control circuit of the circuit-breaker closing coil. Detection via the input signal >Input is also blocked if the circuit breaker is closed or if a protection trip is active.

Internal Manual Closure

Manual closure is detected in all cases if a close command is transmitted by the internal control function of the device. This is possible because the control carries out plausibility checks itself and is also subject to interlocking.

5.9.9.2 Application and Setting Notes

Input Signals: >Input, >Blocking of Manual Closure

In practice, the input signal >Input is connected directly to the control circuit of the circuit-breaker closing coil (see following figure)

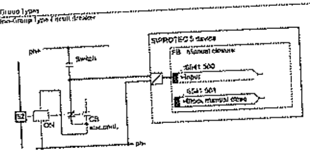

Figure 5-81 Connection of the Input Signal to the Control Circuit of the Circuit-Breaker Closing Coil

Every closure of the circuit breaker is recorded in the process.

If external close commands are possible (actuation of the circuit breaker by other devices), which are not intended to prompt detection of a manual closure, this can be ensured in 2 ways.

- The input signal is connected in such a way that it is not activated in the event of external close commands.
- The external close command is connected to the blocking input >Block manual close for manual closure detection.

Parameter: Action time

- Recommended setting value (_:101) `Action time` = 300 ms

In order to ensure independence from manual activation of the input signal, the detection function is extended for a defined length of time using the parameter `Action time`.

Siemens recommends an action time of 300 ms.

5.9.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s

5.9.9.4 Information List

No.	Information	Data Class (Type)	Type
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O

5.10 Function-Group Type Analog Units

5.10.1 Overview

The Analog units function group is used to map analog units and communicate with them. Analog units are external devices, such as RTD units, or analog plug-in modules, such as the measuring-transducer modules.

You will find the Analog units function group for many device types in the Global DIGSI 5 library.

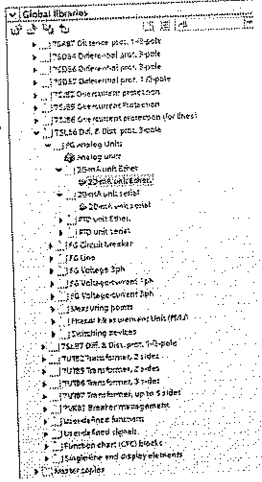

Figure 5-82 Analog Units Function Group in DIGSI

5.10.2 Structure of the Function Group

If the device has a measuring transducer, it is automatically mapped in the Analog units function group. If one or more RTD units are connected to the device, you have to load one or more RTD unit Ether. or RTD unit serial functions from the Global DIGSI library in order to map the RTD units.

The following figure shows the structure of the function group.

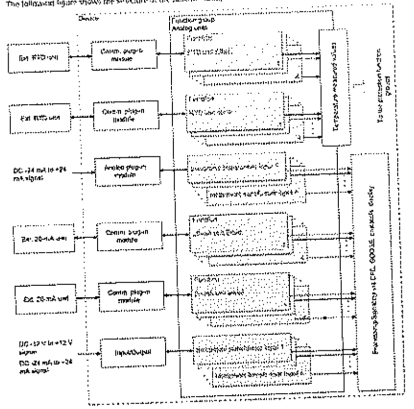

Figure 5-83 Structure of the Analog Unit Function Group

The Analog units function group has interfaces to protection function groups. The Analog units function group provides measured temperature values that come from an external RTD unit. These measured temperature values are available for all protection function groups in which a temperature monitoring function works.

The RTD unit Ether. function is not preconfigured by the manufacturer. A maximum of 20 function instances can work simultaneously.

The RTD unit serial function is set up structurally exactly in the same manner as the RTD unit Ether. function.

5.10.3 20-mA Unit Ethernet

5.10.3.1 Overview

The function 20-mA unit Ether.:

- Communicates in series with a 20-mA unit via the Slave Unit Protocol (SUP) and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process tags such as temperature or gas pressure
- Makes the recorded process tags available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

5.10.3.2 Structure of the Function

The function 20-mA unit Ether. can work only in the function group Analog units. A maximum of 4 function instances can work simultaneously. Each instance contains 12 preconfigured channel function blocks.

The function 20-mA unit Ether. contains input and output channels which can be configured independently of one another.

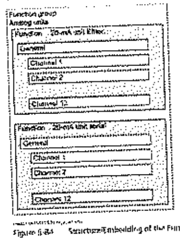

Figure 5-84 Structural Embedding of the Function

5.10.3.3 Communication with 20-mA Unit Ethernet

Logic

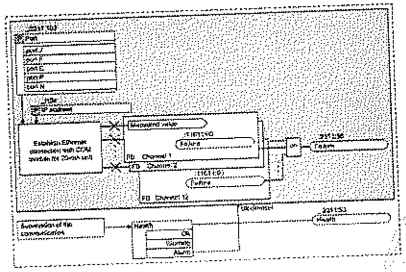

Figure 5-85 Logic of the Function 20-mA Unit Ethernet

Communication with 20-mA Unit

The function is used to communicate with a 20-mA unit connected via an Ethernet connection. When a connection of the function to an external 20-mA unit via an Ethernet interface has successfully been established, the 20-mA unit sends the measured values of all connected channels to the function 20-mA unit Ether. For the connection to be established successfully, specific communication settings must be specified. You can find more detailed information in Chapter 5.10.3.4 Application and Setting Notes.

The 20-mA measurement unit 7XV5674 is supported.

Error Responses

The following table lists the conditions under which the Health status transitions to the Alarm or Warning state.

Table 5-19 Error Responses

Error Description	Status Health
The function 20-mA unit Ether. cannot establish a connection with a communication module.	Alarm
The function 20-mA unit Ether. sends TCP settings to the communication module, which evidently would like to connect to the 20-mA unit via a serial protocol. This communication module does not establish a connection to the 20-mA unit.	Alarm
The connection between the communication module and the 20-mA unit causes a time-out indication.	Warning

Error Description	Status Health
A communication module has not received any more data from the 20-mA unit for 9 sec.	Warning

The Failure signal is set as soon as one of the channel function blocks reports a failure.

5.10.3.4 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = port J

Use the Port setting to define the port connecting the 20-mA unit to the SIPROTEC 5 device.

Parameter: IP address

- Default setting (_:2311:104) IP address = 10.16.60.1

With the IP address settings, you set the IP address of the 20-mA unit connected to the communication module via the TCP protocol. You must assign each 20-mA unit an unambiguous IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. First set an IP address for the 7XV5674 20-mA unit. Then specify the IP address settings for the communication module to the same address.

Settings on the 20-mA Unit

The 7XV5674 20-mA unit is set with a web browser on the laptop computer via the latter's Ethernet interface. Set Modbus TCP as bus protocol operating mode.

You can find detailed notes on the settings in the 7XV5674 manual that accompanies the 20-mA unit. The documents are also available in the SIPROTEC download area.

5.10.3.5 20-mA Channel

Logic

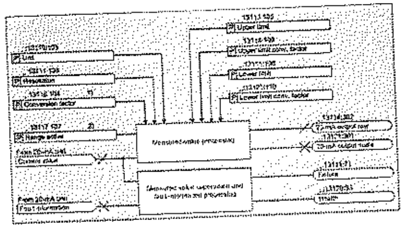

Figure 5-86 Logic Diagram of the Function 20-mA Channel

(1) If the setting Range active is set to true, the setting Transformation ratio is not displayed.

(2) If the setting Range active is set to false, the settings Upper limit, Transformation ratio upper limit, Lower limit and Transformation ratio are not displayed.

Measured-Value Calculation

The function 20-mA channel processes a single 20-mA current signal supplied by the 20-mA unit of the corresponding channel. The 20-mA current measured value is converted into the correct physical quantities such as temperature or pressure. In each 20-mA functional unit (Ether. and serial) there are always 12 of the 20-mA channel function blocks, even if fewer channels are connected with the 20-mA unit. The calculated values are available for further processing via CFC, GOOSE, protocols, and the display image.

Measured-Value Processing

The 20-mA unit typically transmits a value which represents a physical quantity, such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that maps the physical quantity to the 20-mA value. If you do not activate the Range active setting (no x in the check box), the function operates over the range 0 mA to 20 mA. If a value smaller than 0 mA or greater than 20 mA is active at the input of the 20-mA unit, the measured value is identified as invalid. The scaling of the range for the scaled value goes from a usable range of 0 mA to 20 mA. The following figure shows an example.

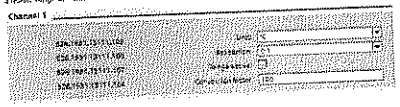

Figure 5-87 Settings for Example 1

In this example, the measured value 0 mA means a temperature of 0 °C and the measured value 20 mA means a temperature of 100 °C. So enter as Unit = °C and Conversion factor = 100. The resolution (decimal places) of the temperature value can be chosen; for a decimal place, select Resolution = 0.1.

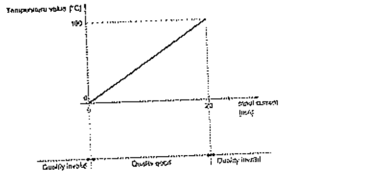

Figure 5-88 Characteristic Curve of a 20-mA Input (Example 1)

655

If you activate the Range active setting, then 4 additional settings Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor appear. The parameters Upper limit and Lower limit indicate the range of the input current in mA. The setting Upper limit - Sensor is the calculated measured value if the input current corresponds to the value in the Upper limit setting. The setting Lower limit - Sensor is the calculated measured value if the input current corresponds to the value in the Lower limit setting. The setting of the range for the scaled value corresponds to the settable range between Lower limit and Upper limit (see following figure).

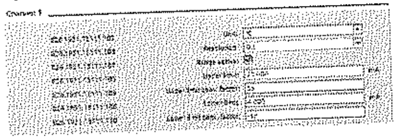

Figure 5-89 Settings for Example 2

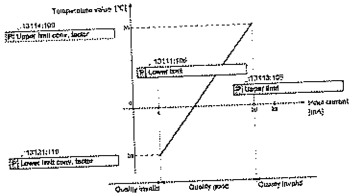

Figure 5-90 Characteristic Curve of a 20-mA Unit (Example 2)

In this example, the Range active setting is selected. The setting Upper limit is at 20 mA, the setting Lower limit is at 4 mA. The setting Upper limit - Sensor is at 55 and the setting Lower limit - Sensor is at -33. If the input current is smaller than 4 mA or greater than 20 mA, the quality of the scaled measured value in this example is invalid.

Each 20-mA channel makes available the scaled measured value in the information routing (these are the temperature values in the examples) and the original current measured value in mA for further processing. The 20-mA values can be displayed in the display page and processed with CFC charts.

Error Responses

If the current input value is determined to be incorrect, the quality attribute of the output value is set to invalid for that status for Health and the defect status assumes the states displayed in the table.

Table 5-20 Error Responses

Error Description	Status Health	Error Status
The input value lies outside the given limits	OK	Yes
Channel not connected	OK	No

5.10.3.6 Application and Setting Notes

Parameter: Unit

- Default setting (_:13111:103) Unit = °C

You use the setting Unit to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting (_:13111:104) Conversion factor = 100

The Conversion factor setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting (_:13111:108) Resolution = 0.1

The Resolution setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting (_:13111:107) Range active = false

If you do not activate the Range active setting (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA.

If you activate the Range active setting, then 4 additional settings Upper limit, Upper limit - Sensor, Lower limit, and Lower limit - Sensor appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting (_:13111:105) Upper limit = 20.00 mA
- Default setting (_:13111:109) Upper limit - Sensor = 100
- Default setting (_:13111:106) Lower limit = 4.00 mA
- Default setting (_:13111:110) Lower limit - Sensor = 100

If you activate the Range active setting, then 4 additional settings Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor appear. The setting Upper limit - Sensor is the calculated measured value if the input current corresponds to the value in the Upper limit setting. The setting Lower limit - Sensor is the calculated measured value if the input current corresponds to the value in the Lower limit setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.10.3.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
Channel 1				
_:13111:103	Channel 1:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • kWh • h • lb • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • Wh • Wh	m
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-10000 to 10000	100

5.10.3.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.10.4 20-mA Unit Serial

5.10.4.1 Overview

The function 20-mA unit Serial:

- Provides serial communications with a 20-mA unit via the Modbus protocol and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process variables such as temperature or gas pressure
- Makes the recorded process data available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

The function 20-mA unit Serial is structured in the same way as the function 20-mA Unit Ether.. The mode of operation is also identical. The only difference is that the measured values are transferred to the communication module via a serial connection instead of an Ethernet connection.

You can find more information in Chapter 5.10.1.2 Structure of the Function.

5.10.4.2 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = Port J

With the Port setting, you specify the slot for the communication module that will be used for the connection with an external 20-mA unit.

Parameter: Channel number

- Default setting (_:2311:105) Channel number = 1

A serial communication module optionally uses 2 channels. With the Channel number setting, you specify the channel number (1 or 2) used to connect the 20-mA unit to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting (_:2311:106) Slave address = 1

Use the Slave address setting to define the device address of the 20-mA unit. If only one 20-mA unit is connected to the serial bus, the default value 1 can be used. Set the same device address as used with the 20-mA unit. The device address is important for distinguishing several 20-mA units that are connected to a serial bus. Set an unambiguous device address on every 20-mA unit, for example, 1, 2 and 3 when connecting 3 of the 20-mA units. On every 20-mA unit, set for the Slave address setting in the 3 functions 20-mA Unit Serial the same device address for each.

Parameter: Unit

- Default setting (_:13111:103) Unit = °C

You use the setting Unit to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

- Default setting (_:13111:104) Conversion factor = 100

The Conversion factor setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting (_:13111:108) Resolution = 0.1

The Resolution setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting (_:13111:107) Range active = false

If you do not activate the Range active setting (no x in the check box), the function operates over the range 0 mA to 24 mA. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA.

If you activate the Range active setting, then 4 additional settings Upper limit, Upper limit - Sensor, Lower limit and Lower limit - Sensor appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting (_:13111:105) Upper limit = 20 mA
- Default setting (_:13111:109) Upper limit - Sensor = 100
- Default setting (_:13111:106) Lower limit = 4 mA
- Default setting (_:13111:110) Lower limit - Sensor = 100

If you activate the Range active setting, then 4 additional settings Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor appear. The setting Upper limit - Sensor is the calculated measured value if the input current corresponds to the value in the Upper limit setting. The setting Lower limit - Sensor is the calculated measured value if the input current corresponds to the value in the Lower limit setting.

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.10.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 247	1
Channel 1				
_:13111:103	Channel 1:Unit		• % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • kWh • h • lb • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • Wh • Wh	m

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:13111:357	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		1.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-10000 to 10000	100

5.10.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20 mA output value	MV	O
_:13111:302	Channel 1:20 mA output raw	MV	O

5.10.5 Communication with 20-mA Unit

5.10.5.1 Integration of a Serial 20-mA Unit

Connection of the Communication Lines

Figure 5-91 shows how to connect the 20-mA unit to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.

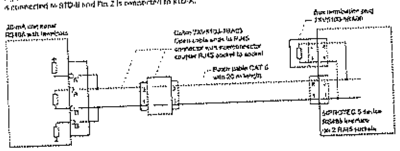

Figure 5-91 Connection of the 20-mA Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or a USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

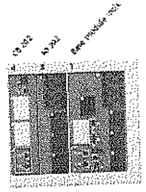

Figure 5-92 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the 20-mA unit.

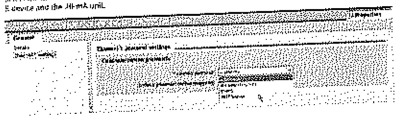

Figure 5-93 Selecting the SUP Protocol

Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the 20-mA unit. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the 20-mA unit. Make sure that the setting values in both devices are the same. The settings of the Pers. Blackening Light (on/off) is not relevant for the RS485 interface.

> **NOTE**
>
> The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).

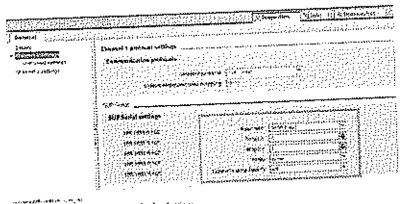

Figure 5-94 Making the Communication Settings

With the selection of the SUP protocol for the 20-mA unit, DIGSI automatically adds the function group Analog units to your device configuration. You can now instantiate the function 20-mA unit serial 1 (see following figure).

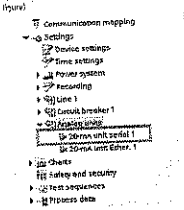

Figure 5-95 Insertion of the Function 20-mA Unit Serial 1

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the 20-mA unit. This address must be set with the same value in the 20-mA unit (refer to the following figure).

For the first use of the 20-mA unit, the following device configuration must be set on the 20-mA unit:

- Bus protocol: Mod
- Device address: 1
- Baud rate: 9600
- Parity: no

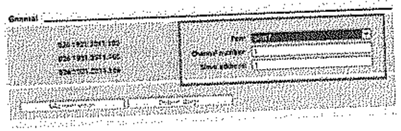

Figure 5-96 Setting the Port, Channel Number, and Device Address

Finally, load the configuration in the device.

5.10.5.2 Integration of a 20-mA Unit Ethernet

Device Configuration

In DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. Figure 5-97 displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

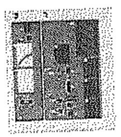

Figure 5-97 Inserting an Ethernet Module

Communication Settings

Activate the SUP Ethernet protocol for the Ethernet module.

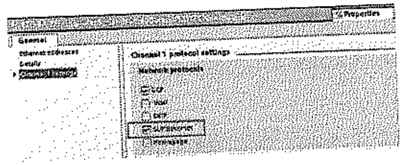

Figure 5-98 Activation of the protocol

This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).

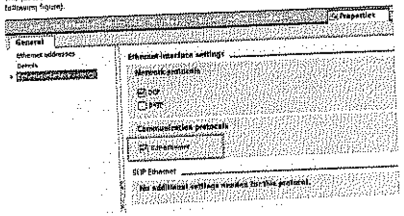

Figure 5-99 Selection of the Protocol

With the selection of the SUP protocol for the 20-mA unit, DIGSI automatically adds the Analog units function group and the 20-mA unit Ether. function to your device configuration (refer to the following figure).

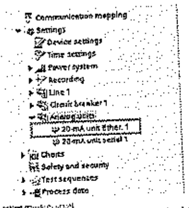

Figure 5-100 Insertion of the Function 20-mA Unit Ether. 1

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the 20-mA unit (refer to the following figure). This address must be set with the same value in the 20-mA unit.

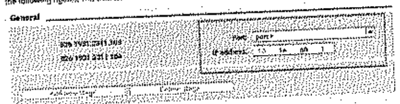

Figure 5-101 Setting the Port and IP Address

Finally, load the configuration in the device.

5.10.6 V/I-Measuring-Transducer Unit with Fast Inputs

5.10.6.1 Overview

The fast analog measuring-transducer inputs process voltage values (DC -10 V to +10 V) as well as current values (DC -20 mA to 20 mA).

The function MT fast inputs:

- Provides sampled values for recording in the fault record (the maximum sampling frequency is 8 kHz for all other SIPROTEC 5 devices). The recorded sampling frequency results from the setting of the fault recorder function.
- Calculates measured values from the sampled values. These measured values have been deduced from the arithmetic mean values. The measuring range for the mean-value calculation is adjustable in the interval from 10 ms to 100 ms.

- Converts the measured current or voltage values into process values, for example, temperature, gas pressure, etc.
- Provides the recorded process variables for further processing in the fault recorder, the CFC, and in GOOSE-applications for communication via communication protocols, and for visualization.

The fast measuring-transducer inputs are located on the IO212 module with 8 inputs (optionally current or voltage inputs), and the IO210 module with 4 inputs (optionally current or voltage inputs).

5.10.6.2 Structure of the Function

The function MT fast input works in the function group Analog units and contains the number of available measuring-transducer inputs, depending on the hardware configuration. You can configure these channels independently from one another either as current or voltage inputs.

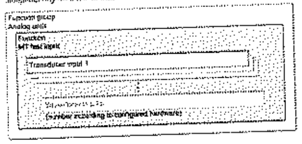

Figure 5-102 Structure/Embedding of the Function

5.10.6.3 Function Description

Once you have instantiated the MT fast input function, it will be visible in the project tree in the function group Analog units. You can find the function group Analog units in DIGSI in the Settings folder.

If you open the subdirectory MT fast input, you reach the settings sheet for the respective input (for more details, see Application and Setting Notes).

The hardware is designed in such a way that either a current or a voltage can be processed at each input. Use the corresponding terminals (see Hardware manual). Configure the input in accordance with the selected connection (Parameter TD input-signal type). With the parameter Measuring window, you set the measuring range within which the arithmetic mean value is determined. With the parameter Measuring window, you also determine measurement speed for the input. For example, a setting of 100 ms means that the measured value is updated every 100 ms.

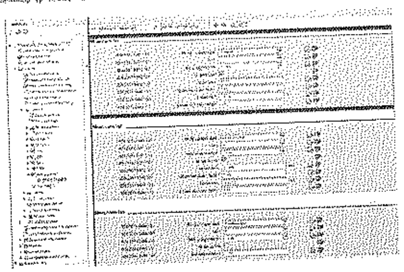

Figure 5-103 Parameters of the Measuring Transducer Channels

The fast measuring-transducer channels can be configured either as current or as voltage inputs. Apart from this, this function corresponds to the basic function of the 20-mA channels (see chapter 5.10.3 20-mA Channel).

5.10.6.4 Application and Setting Notes

Parameter: TD input-signal type

- Default setting (_:101) TD input-signal type = Current input

With the parameter TD input-signal type, you determine whether the measuring-transducer input channel works as a Current input or as a Voltage input.

Make sure that the selected channel has also been wired correctly (see Hardware manual, Input and Output Module IO212).

Parameter: Unit

- Default setting (_:103) Unit = A

With the parameter Unit, you set the physical unit of measurement of the measured values. The possible setting values are listed in the settings table.

Parameter: Measuring window

- Default setting (_:112) Measuring window = 10 ms

With the parameter Measuring window, you set the measuring window that is used to determine the arithmetic mean value from the sampled values. In case of slowly varying signals, Siemens recommends setting the top value to 100 ms. With this value, a new, current measured value is provided every 100 ms for further processing.

Parameter: Range active

- Default setting (_:107) Range active = false

If you do not activate the Range active parameter, the function assumes a range of -20 mA to +20 mA or -10 V to +10 V. The setting of the range for the scaled value then assumes a range range of -20 mA to +20 mA or -10 V to +10 V.

If you activate the Range active parameter, then 4 additional parameters Upper limit, Upper limit - Sensor, Lower limit, and Lower limit - Sensor appear.

Note that this setting is activated by either placing, or not placing the relevant check mark in DIGSI (see Figure 5-103).

Parameter: Conversion factor

- Default setting (_:104) Conversion factor = 1.00

With the parameter Conversion factor, you set the conversion factor for the measuring transducer.

Parameter: Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor

With the following parameters, you set the scaling of the measuring variables. By that, you can scale in an application-specific way:

- Default setting Upper limit = 20.00 mA
- Default setting Upper limit - Sensor = 1.00
- Default setting Lower limit = -20.00 mA
- Default setting Lower limit - Sensor = 1.00

With these setting parameters, you set the operating range of the measuring transducer as well as the conversion of the values transmitted to the sensor values. Harmonize the operating range of the measuring transducer with the transmitter of the sensor. Using the free scalability of the system, you can meet different requirements. The following figure shows the setting parameters in general terms.

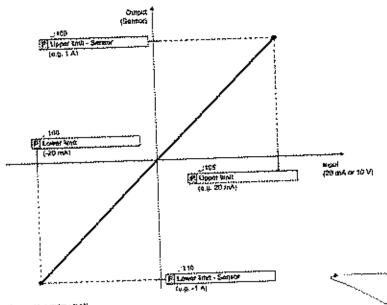

Figure 5-104 Scaling Principle

Setting Example 1:

A measuring transducer transmitting a current signal at 4 mA to 20 mA is used as a transmitter. Currents well below 4 mA indicate a transmitter failure; currents around 0 mA indicate a broken wire. A sensor detecting a temperature is attached to the transmitter. The upper value corresponds to 200 °C and the lower value to -100 °C. This results in the following characteristic. In accordance with the set characteristic curve, the function calculates the sensor value from the measured current. The coefficients of the linear equation (gradient and foot point) are calculated from the set threshold and the sensor values are determined. A supplied current of 9.333 mA corresponds to a temperature of 0 °C.

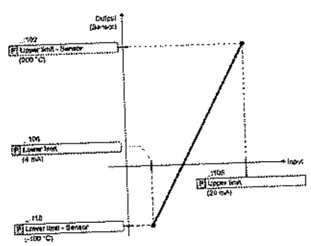

Figure 5-105 Characteristic Curve of Setting Example 1

> **NOTE**
>
> The hardware of the measuring transducer has been designed in such a way that measured values are transmitted and analyzed using the setting range (Upper limit or Lower limit). Therefore, special applications are possible, if necessary. The limits lie at approximately +20 mA and -20 mA or +10 V and -10 V. If the measured values are supplied above or below these limits, the quality attribute is assigned.

Setting Example 2:

For special applications, the transmitter sends a maximum of ±12 V. This voltage shall be issued accordingly as sensor voltage.

Set the parameters as follows:

- Upper limit = 10.00 V
- Upper limit - Sensor = 10.00 V
- Lower limit = -10.00 V
- Lower limit - Sensor = -10.00 V

With this setting, a signal of 12 V is issued as a 12 V measured value (see following figure).

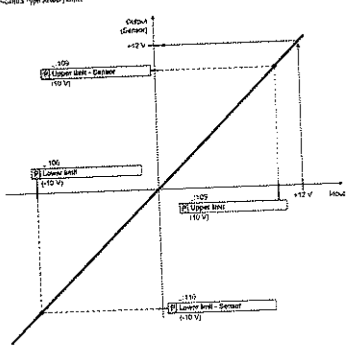

Figure 5-106 Parameter Settings and Representation of an Input Signal Greater than 10 V

5.10.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT fast #				
_:101	MT fast #:TD input-signal type		• Voltage input • Current input	Current input

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Addr.	Parameter	C	Setting Options	Default Setting
_:101	MT in #:Unit		• • % • ° • °C • °F • Ω • Ohm/km • Ohm/mi • 1/s • A • As • cos φ • cycles • dB • ft/km • ft/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • m³ • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	A
_:142	MT in #:Measuring window		• 10 ms • 20 ms • 40 ms • 60 ms • 80 ms • 100 ms	10 ms
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		-10000.00 to 10000.00	1.00
_:105	MT in #:Upper limit		-20.00 mA to 20.00 mA	5.00 mA
_:106	MT in #:Upper limit - Sensor		-100000.00 to 100000.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Lower limit		-20.00 mA to 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-100000.00 to 100000.00	1.00

5.10.6.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:302	MT in #:TD scale MV	MV	O
_:306	MT in #:TD scale SAV	SAV	O

5.10.7 RTD Unit Ethernet

5.10.7.1 Overview

The RTD unit Ether. function:

- Communicates with an external RTD unit via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature monitoring function
- Monitors communication with the RTD unit

5.10.7.2 Structure of the Function

The RTD unit Ether. function can only work in the Analog units function group. A maximum of 20 function instances can work simultaneously. Each instance contains 12 preconfigured sensor function blocks.

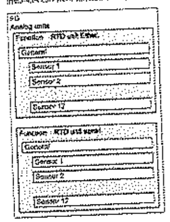

Figure 5-107 Structure/Embedding of the Function

5.10.7.3 Communication with an RTD Unit

Logic

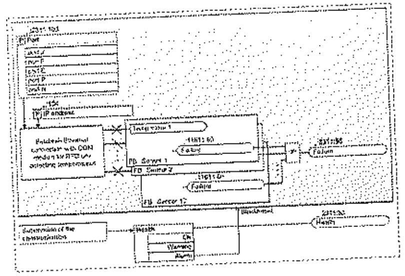

Figure 5-108 Logic of the RTD Unit Ether. Function

Communication with an RTD Unit

The function is used to communicate with an RTD box connected via an Ethernet connection. If the connection of the function is successfully established to the external RTD box via the Ethernet interface, the RTD box transmits the temperatures of all connected sensors to the RTD box Ether. function. For the connection to be established successfully, specific communication settings must be set, see chapter 5.10.7.4 Application and Setting Notes.

The RTD box Ziehl TR1200 IP supports only an Ethernet connection of 10 Mbit/s. A direct connection to a 100-Mbit communication module is therefore not possible. For this reason, you must connect the RTD box to the communication module via a 10/100 Mbit autosensing switch which automatically recognizes the transmission rates and adapts them accordingly. Further information can be found in the Application and Setting notes, see chapter 5.10.7.4 Application and Setting Notes.

Error Responses

The following table lists the conditions under which the Health status transitions to the Alarm or Warning state.

Table 5-21 Error Responses

Error Description	Status Health
The RTD unit Ether. function cannot establish a connection with a communication module.	Alarm
The connection between the communication module and the RTD unit causes a time-out.	Warning

Error Description	Status Health
A communication module has not received any more data from the RTD unit for 9 s.	Warning

The Failure signal is set as soon as one of the sensor function blocks reports a failure.

5.10.7.4 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = port J

Use the Port parameter to define over which port the external RTD unit is connected to the SIPROTEC 5 device.

If you want to connect the external RTD unit to the integrated Ethernet interface, set the parameter Port = Port J. If you want to connect the external RTD unit to an Ethernet plug-in module, set the parameter Port = Port F, Port E, Port P, or Port N.

You can connect directly the RTD unit to the device via the internal 10-Mbit Ethernet port J. If you operate the RTD unit on another port via a 100-Mbit communication module, you need an interconnected 10/100-Mbit autosensing switch, which adapts transmission rates accordingly.

Parameter: IP address

- Default setting (_:2311:104) IP address = 10.16.60.1

With the IP address parameter, you set the IP address of the RTD unit connected to the communication module via the SUP protocol. Every RTD unit has to be assigned a unique IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. Set an appropriate IP address first at the Ziehl TR1200 IP RTD unit. Then specify the IP address parameter for the communication module to the same address.

Settings on the RTD Unit

The Ziehl TR1200 IP RTD unit is set with the front keys or in a Web browser on a laptop computer via its Ethernet interface. Set the connection type of the sensors (3-wire connection or resistance value for 2-wire connection), the idle state of the fault-indication relay, as well as the IP interface setting.

The code lock has to be switched off for parameterization. This is only possible using the front keys of the RTD unit. The code lock is off (switched off) in as-delivered condition and has pin 504.

For detailed information on the settings, refer to the TR1200 IP manual that comes with the RTD unit. The documents are also available in the SIPROTEC download area (http://www.siprotec.de) under Accessories → 7XV5662-xAD.

For an Ethernet connection to a SIPROTEC 5 device communication with the RTD unit TR1200 IP via the SUP protocol (Slave Unit Protocol), the Modbus TCP setting must be activated in the RTD unit. You can activate the Modbus TCP protocol using the function keys under the TCP - mod menu item or with the Web browser in the TCP/UDP Config tab. The RTD (RTD protocol) and UDP Port settings have no effect here. The Modbus TCP port is permanently set to 502 and cannot be changed.

5.10.7.5 Temperature Sensor

Logic

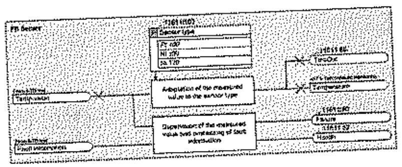

Figure 5-109 Logic Diagram of the Temperature Sensor Function Block

Measured Temperature Value

The Temperature sensor function block processes one single measured temperature value delivered from the RTD box for the assigned sensor. 12 temperature sensor function blocks are always available in each RTD box function (both via Ethernet and serial), even if fewer sensors are connected to the RTD box.

Various temperature sensor types are supported: Pt100, Ni100, and Ni120 sensors. The function block is notified regarding the selection of connected type via the Sensor type parameter.

The function block delivers a measured temperature value in °C or °F as an output variable. The measured temperature value is available as an operational measured value and can be monitored by the Temperature supervision function.

Related Topics

Temperature supervision function, chapter 6.46.3 Function Description

Error Responses

If the measured input value is determined to be incorrect, the quality attribute of the output measured temperature value is set to invalid. The statuses for Health and Error take the statuses in accordance with the following table:

Table 5-22 Error responses

Error Description	Health Status	Error Status
Sensor or line short circuited	Alarm	Yes
Sensor or line interrupted	Alarm	Yes
Measured temperature value outside the valid measuring range specified in the technical data. The valid measuring range depends on the sensor type.	Alarm	Yes
Sensor not connected	OK	No

5.10.7.6 Application and Setting Notes

Parameter: Sensor type

- Default setting (_:11611:102) Sensor type = Pt 100

The Sensor type parameter is used to set the sensor element used. You can select between Pt 100, Ni 100 and Ni 120.

Parameter: Temperature unit

To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly.

Proceed as follows:

- In DIGSI select the menu item Extras → Settings.
- In the Settings view select the menu item DIGSI 5 User preferences.
- Under Standard unit system change the setting value of the unit system used from SI units to US units.

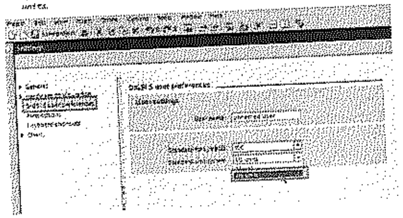

Figure 5-110 Change of the Display Between °C and °F

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.10.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port J • port F • port E • port N • port P	port J
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

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5.10.7.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Sensor 1			
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O

5.10.8 RTD Unit, Serial

5.10.8.1 Overview

The RTD unit serial function:

- Communicates with an external RTD unit serial via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature supervision function
- Monitors communication with the RTD unit

The RTD unit Serial function is set up structurally in the same manner as the RTD unit Ether. function. The mode of operation is also identical (see 5.10.7.1 Communication with an RTD Unit).

5.10.8.2 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = F

With the Port parameter, you set the slot for the communication module that will be used for the connection with an external RTD unit.

If you want to connect the external RTD box to an Ethernet plug-in module, set the parameter Port = Port E, Port F, Port P, or plug-in module position.

Parameter: Channel number

- Default setting (_:2311:105) Channel number = 1

A serial communication module optionally uses 2 channels. With the Channel number settings, you set the channel number (1 or 2) through which the RTD unit is connected to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting (_:2311:106) Slave address = 1

Use the Slave address parameter to define the device address of the RTD unit. If only one RTD unit is connected to the serial bus, the default value 1 can be used. The same device address has to be set on the RTD unit. The device address is important for distinguishing among several RTD units connected to a serial bus. Set a unique device address (for example 1, 2 and 3 when connecting 3 RTD units) for each RTD unit and the same device address for the parameter Slave address in the 3 RTD unit serial functions.

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.10.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port F
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 247	1
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.10.8.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Sensor 1			
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O

5.10.9 Communication with RTD Unit

5.10.9.1 Integration of a Serial RTD Unit (Ziehl TR1200)

Connection of the Communication Lines

Figure 5-111 shows how you connect the RTD box to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.

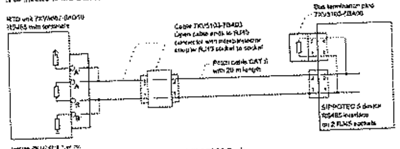

Figure 5-111 Connection of the RTD Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

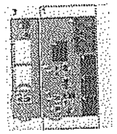

Figure 5-112 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the RTD Unit.

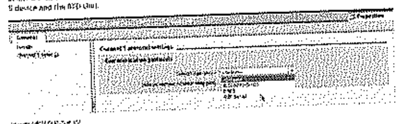

Figure 5-113 Selecting the SUP Protocol

Communication Settings

Make the communication settings for the relevant serial channels. For this, use the default settings specified by the RTD box. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the RTD box. Make sure that the setting values in both devices are the same. The settings of the Non-Flickering light (on/off) is not relevant for the RS485 interface.

> **NOTE**
>
> The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of the interface (following the firmware update).

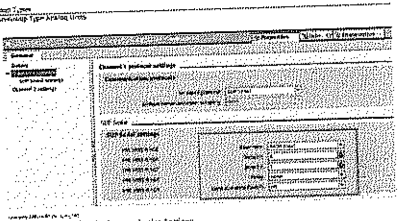

Figure 5-114 Making the Communication Settings

With the selection of the SUP protocol for the RTD box DIGSI automatically adds the function group Analog units to your device configuration. You can now instantiate the function RTD box serial 1 (refer to the following figure).

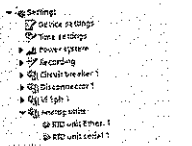

Figure 5-115 Analog-Unit Instance

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the RTD line. This address must be set with the same value in the RTD box (refer to the following figure).

The following device configuration must be set on the TR1200 RTD unit when the RTD unit is used for the first time:

- Bus protocol: rtu
- Device address: 1
- Baud rate: 9600
- Parity: no

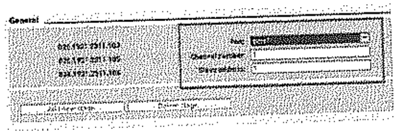

Figure 5-116 Setting the Port, Channel Number, and Slave Address

Finally, load the configuration in the device.

5.10.9.2 Integration of an RTD-Unit Ethernet (TR1200 IP)

Device Configuration

In the DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. Figure 5-117 displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

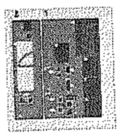

Figure 5-117 Inserting an Ethernet Module

Communication Settings

Activate the SUP Ethernet protocol for the Ethernet module.

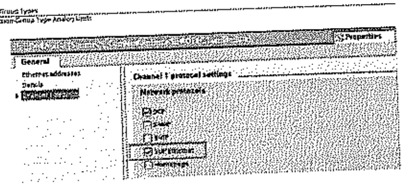

Figure 5-118 SUP Ethernet Protocol Activation

This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).

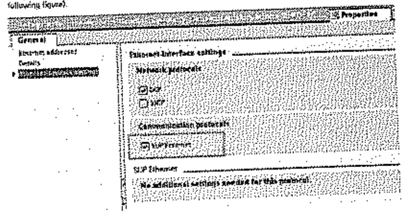

Figure 5-119 SUP Ethernet Protocol Activation (Base module)

With the selection of the SUP protocol for the RTD unit, DIGSI automatically adds the Analog units function group and the RTD unit Ether. function to your device configuration (refer to the following figure).

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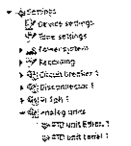

Figure 5-120 Analog Unit Instance

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the RTD box (refer to the following figure). This address must be set with the same value in the RTD box.

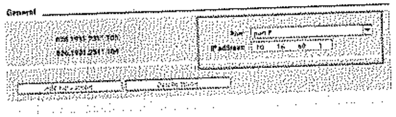

Figure 5-121 Setting the Port and IP Address

Finally, load the configuration in the device.

5.10.9.2 Temperature Simulation without Sensors

Connect a resistor on the sensor terminals of the RTD unit. Using this resistor, simulate a constant temperature. The resistance value should be around 50 Ω to 200 Ω.

If you want to simulate a changeable temperature, connect an adjustable resistor of maximum 470 Ω instead of a fixed resistor.

5.11 Process Monitor

5.11.1 Overview of Functions

All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor detects the current state of the protected object.

5.11.2 Structure of the Function

The Process monitor function is used in the following protection function groups with current measurement:

- Transformer side
- Auto transf. auto side
- Auto Transf. comp. side
- Auto transf. ground side
- Motor Side
- Standard VI

The Process monitor function is provided by the manufacturer with the following function blocks:

- Cold-load pickup detection (optional)
- Current-flow criterion
- Circuit-breaker condition
- Closure detection

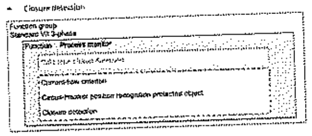

Figure 5-122 Structure/Embedding of the Function

You can activate the cold-load pickup detection as needed. All other stages of the process monitor run permanently in the background and are not displayed in DIGSI.

The following figure shows the relationships of the individual function blocks.

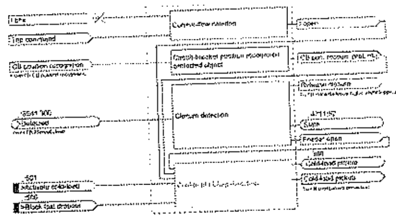

Figure 5-123 Logic Diagram of the Overall Function Process Monitor

5.11.3 Current-Flow Criterion

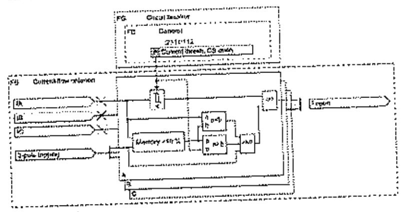

Figure 5-124 Logic Diagram of the Current-Flow Criterion Function Block

The I open signal of one phase is generated if one of the following conditions is met:

- A phase current falls below the set threshold of the Current thresh. CB open parameter. The hysteresis stabilizes the signal.
- The corresponding phase current, for example, I A, falls below 10 % of the phase current when the trip command arrives. If the current does not drop until after a delay due to current transformer influences, an open pole can therefore be detected quickly even after a high-current fault on the line.

With the Current thresh. CB open parameter, you define the minimum current as the criterion for a deactivated line. The parameter lies in the Circuit-breaker function group. It acts both in the Circuit-breaker function group, for example circuit-breaker position recognition, and also for the process monitor in the Protection function group.

5.11.4 Application and Setting Notes (Current-Flow Criterion)

Parameter: Current thresh. CB open

- Recommended setting value (_:2311:112) Current thresh. CB open = 0.100 A

The Current thresh. CB open parameter is used to define the threshold for the leakage current as the criterion for a deactivated line.

Set the Current thresh. CB open parameter so that the current measured when the feeder is deactivated falls below the value of the Current thresh. CB open parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.

If parasitic currents, for example, due to induction, are ruled out when the feeder is deactivated, set the Current thresh. CB open parameter sensitively.

Siemens recommends a setting value of 0.100 A.

5.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

5.11.6 Circuit-Breaker Condition for the Protected Object

Logic

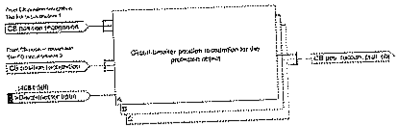

Figure 5-125 Logic Diagram of the Circuit-Breaker Condition for the Protected-Object Function Block

The circuit-breaker position recognition in the Circuit breaker (CB) function group provides the circuit-breaker condition by way of the internal signal CB pos. recogn. prot. obj..

If a protected object is supplied via 2 circuit breakers (CBs), for example with the 1 1/2 circuit-breaker layout, then the circuit-breaker switch position of the protected object must be determined with the aid of both circuit breakers. In this case, the Circuit-breaker position recognition for the protected object function block connects the individual CB states. The connection provides the internal CB pos. recogn. prot. obj. signal to the other function blocks of the process monitor and to other functions, for example, Trip in the event of weak infeed and Echo function for teleprotection method, within the same function group.

If one of the following 2 conditions is met, the CB pos. recogn. prot. obj. signal is in the Open state.

- All connected circuit breakers signal the Open state internally.
- The >Disconnector open input is active.

If the following 2 conditions are met, the CB pos. recogn. prot. obj. signal is in the Closed state:

- At least one of the connected circuit breakers signals the Closed state internally.
- The >Disconnector open input is not active.

5.11.7 Closure Detection

The closure detection enables the immediate tripping of selected protection functions or protection stages when switching to a short circuit or the reduction of the responsivity. The closure detection determines whether the protected object is switched on.

Logic

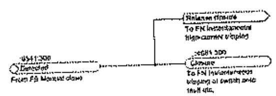

Figure 5-126 Logic Diagram of Closure Detection

For an applied binary input signal Detected (from Manual close function block), the indication Closure is active.

5.11.8 Information List

No.	Information	Data Class (Type)	Type
Closure detec.			
_:4681:500	Closure detec.:>Disconnector open	SPS	I
_:4681:300	Closure detec.:Closure	SPS	O

5.11.9 Cold-Load Pickup Detection (Optional)

Logic

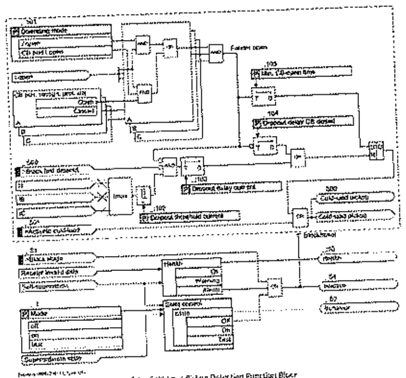

Figure 5-127 Logic Diagram of the Cold-Load Pickup Detection Function Block

The Cold-load pickup detection function block detects that a specific time has been exceeded after deactivation of the line or protected object. If you want to connect the protected object again, you must note that an increased load current requirement exists for a limited time after connection. This results from the nature of the load.

The Cold-load pickup detection function block ensures that different parameters are used for an adjustable time after connection. For example, for the time of the Max. CB-open time parameter, you can increase the threshold value of a protection function or you can select a special characteristic curve.

If the Cold-load pickup detection function block detects an open feeder and the set time of the Max. CB-open time parameter has expired, the indication >Activate cold-load is generated.

With the >Activate cold-load indication, you can activate a parameter set of the Cold-load pickup function. Via the binary input signal >Activate cold-load, you can also activate the >Activate cold-load indication directly.

If the Cold-load pickup detection function block detects closure and the corresponding load current, it starts the time set in the Dropout delay CB closed parameter. The >Activate cold-load indication and the activated parameter set are deactivated after this time has elapsed.

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If, for the time set in the Dropout delay curr.crit. parameter, the maximum phase current falls below the threshold value Dropout threshold current, the parameter set for the Cold-load pickup detection function block is also deactivated. As a result, if the load current is very low, the action time Dropout delay curr.crit. of the parameter Cold-load indication can be shortened.

5.11.10 Application and Setting Notes (Cold-Load Pickup Detection)

NOTE

The settings and instructions described in this chapter are only available when using the optional Cold-load pickup detection function block.

Parameter: Operating mode

- Default setting (_:101) Operating mode = I open

With the Operating mode parameter, you set the criteria with which the Closure-detection function block operates.

Parameter Value	Description
I open	When the Current-flow criterion function block detects a clearing open condition, the decision is made for pickup. For this setting, make sure that the Current thresh. CB open parameter is set lower than the possible load current. If this is not the case, open is detected continuously and each fault current that exceeds the Current thresh. CB open parameter is interpreted as closure.
CB and I open	Closure is detected if one of the following conditions is met: • Analysis of the circuit-breaker auxiliary contact detects a clearing open condition in at least one phase. • The current-flow criterion detects a clearing open condition

Parameter: Dropout threshold current

- Default setting (_:102) Dropout threshold current = 1.00 A

With the Dropout threshold current parameter, you set the threshold at which the output signal Cold-load pickup is deactivated when the current in at least one phase falls below this threshold.

Parameter: Dropout delay current criterion

- Default setting (_:103) Dropout delay curr.crit. = 600 s

With the Dropout delay curr.crit. parameter, you set the time for which the actual value must be below the Dropout threshold current threshold so that the output signal Cold-load pickup can be deactivated prematurely.

Parameter: Dropout delay CB closed

- Default setting (_:104) Dropout delay CB closed = 3600 s

With the Dropout delay CB closed parameter, you set the action time for the dynamic parameter set switching in the event of cold-load pickup detection.

Parameter: Min. CB open time

- Default setting (_:105) Min. CB-open time = 3600 s

With the Min. CB-open time parameter, you set the time after which the dynamic parameter set is activated in the event of cold-load pickup when the line is opened.

5.11.11 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Cold-load PU				
_:1	Cold-load PU:Mode		• off • on • test	off
_:101	Cold-load PU:Operating mode		• I open • CB and I open	I open
_:102	Cold-load PU:Dropout threshold current	1 A @ 100 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:103	Cold-load PU:Dropout delay curr.crit.		1 s to 600 s	600 s
_:104	Cold-load PU:Dropout delay CB closed		1 s to 21600 s	3600 s
_:105	Cold-load PU:Min. CB open time		0 s to 21600 s	3600 s

5.11.12 Information List

No.	Information	Data Class (Type)	Type
Cold-load PU			
_:81	Cold-load PU:>Block stage	SPS	I
_:500	Cold-load PU:>Block fast dropout	SPS	I
_:501	Cold-load PU:>Activate cold-load	SPS	I
_:54	Cold-load PU:Inactive	SPS	O
_:52	Cold-load PU:Behavior	ENS	O
_:53	Cold-load PU:Health	ENS	O
_:300	Cold-load PU:Cold-load pickup	SPS	O

6 Protection and Automation Functions

6.1 Power-System Data

6.1.1 Overview

The Power-system data are provided with each SIPROTEC 5 device and cannot be deleted. You will find them in DIGSI under Settings → Power system.

6.1.2 Structure of the Power-System Data

The Power-system data contain the block General and the Measuring points of the device. The following figure shows the structure of the Power system data:

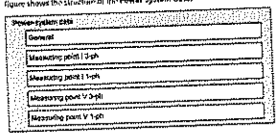

Figure 6-1 Structure of the Power-System Data

In order to adjust its functions to the application, the device requires some data about the power system. The necessary settings can be found in the Power-system data under General as well as in the Measuring points.

NOTE

You can find information on the supervision function parameters in chapter 8.3 Supervision of the Secondary System.

Type and scope of the required measuring points depend on the application. Possible measuring points are:

- Voltage 3-phase (measuring point V 3-ph)
- Current 3-phase (measuring point I 3-ph)
- Voltage 1-phase (measuring point V 1-ph)
- Current 1-phase (measuring point I 1-ph)

The measuring points have interfaces to the function groups requiring voltage and/or current measured values of the power system.

6.1.3 Application and Setting Instructions - General Settings

Parameter: Phase sequence

- Recommended setting value (_:2311:101) Phase sequence = ABC

The parameter Phase sequence is used to set the phase sequence (ABC) or (ACB). The setting value applies to the entire SIPROTEC 5 device.

Use the General function to set the settings in the power-system data.

You can find detailed information about phase-rotation reversal in chapter 6.42 Phase-Rotation Reversal.

6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)

The following example describes the settings of the voltage measuring point Measuring point V-3ph (Voltage 3-phase). The V-1ph measuring point has only a subset of the parameters described here. The description of the parameter is also valid for the V-1ph measuring point.

Parameter: Rated primary voltage

- Default setting (_:8911:101) Rated primary voltage = 400 kV

The Rated primary voltage parameter is used to set the primary rated voltage of the voltage transformer.

Parameter: Rated secondary voltage

- Default setting (_:8911:102) Rated secondary voltage = 100 V

The Rated secondary voltage parameter is used to set the secondary rated voltage of the voltage transformer.

Parameter: Matching ratio Vph / VN

- Default setting (_:8911:103) Matching ratio Vph / VN = 1.73

The Matching ratio Vph / VN parameter is used to set the deviation between the calculated zero-sequence voltage and the residual voltage measured directly via a measuring input. The different ratio of the voltage transformers is the cause for the deviation (see Figure 6-2).

The Matching ratio Vph / VN is equal to the ratio $3V_{0sec}/V_{Nsec}$

with

V_{0sec} Calculated zero-sequence voltage

V_{Nsec} Measured residual voltage

The zero-sequence voltage is calculated as phase-to-ground voltages. The residual voltage is measured on the broken-delta winding of the voltage transformer. For 1-phase voltage transformers, the residual voltage is measured at the generator or the transformer neutral point.

NOTE

The measured residual voltage V_{Nsec} is converted to a zero-sequence voltage in the device as follows:

$$V_{0sec} = V_{Nsec} \cdot \frac{\text{Matching ratio Vph/VN}}{3}$$

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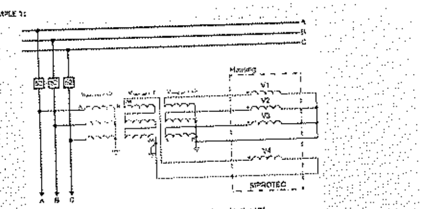
EXAMPLE 1:



Voltage transformer 3-phase: connection = 3 ph-to-gnd volt. + VN

Figure 6-2 3-Phase Voltage Transformer, Connection = 3 Phase-to-Ground Voltage + VN

When the type of connection for the voltage transformer = 3 ph-to-gnd volt. + VN is (parameter VT connection) and the voltage input V4 is connected to the broken delta winding of the voltage transformer (da/dn), the Matching ratio Vph / VN is as follows:

When changing the neutral point according to Figure 6-2, this results in the following values:

- The calculated secondary zero-sequence voltage V_{0sec} is equal to the secondary phase-to-ground voltage. Expressed as secondary transformer rated voltage, then $V_{rated sec}/\sqrt{3}$.
- The measured residual voltage on the broken-delta winding is the sum of the voltage drops on the 3 sides. Expressed with the side ratio, the result is $V_{N sec} = 3 \cdot V_{rated sec}/3$.

Calculate the Matching ratio Vph / VN parameter as follows:

$$\text{Matching ratio } \frac{Vph}{VN} = \frac{3 \cdot V_{0\,sec}}{V_{N\,sec}} = \frac{3 \cdot \frac{V_{rated\,sec}}{\sqrt{3}}}{3 \cdot \frac{V_{rated\,sec}}{3}} = \frac{3}{\sqrt{3}} = \sqrt{3} = 1.73$$

Set Matching ratio Vph / VN = 1.73.

In example 1 $V_{rated\,sec}$ the phase-to-ground voltage and the secondary voltage on the broken-delta winding were identical. If these voltages are different, use the actual numerical values in the calculation.

EXAMPLE 2:

Phase-to-ground voltage	$V_{rated\,sec}$ = 100 V
Broken-delta winding (for example, grounding transformer in generator protection)	$V_{rated\,sec}$ = 500 V The voltage input of the device is designed for a continuous operation using 230 V max. Therefore, the voltage on the broken-delta winding (500 V) is reduced to a 5/2 ratio, using an ohmic divider. In order to calculate the matching factor, the secondary voltage of 200 V will be applied.

Calculate the Matching ratio Vph / VN parameter as follows:

$$\text{Matching ratio } \frac{Vph}{VN} = \frac{3 \cdot V_{0\,sec}}{V_{N\,sec}} = \frac{3 \cdot \frac{V_{rated\,sec}}{\sqrt{3}}}{3 \cdot \frac{V_{N\,sec}}{3}} = \frac{3 \cdot \frac{100\ V}{\sqrt{3}}}{3 \cdot \frac{200\ V}{3}} = \frac{3}{2 \cdot \sqrt{3}} = \frac{\sqrt{3}}{2} = 0.866$$

Set Matching ratio Vph / VN = 0.866.

Interpretation of the results:

The zero-sequence voltage calculated from the phase-to-ground voltage is 57.73 V (= 100 V/√3). The measured residual voltage is 200 V. The calculated matching factor is 0.866. The measured residual voltage is converted to a zero-sequence voltage inside the device:

$$V_{0\,sec} = V_{N\,sec} \cdot \frac{\text{Matching ratio Vph/VN}}{3} = 200\ V \cdot \frac{0.866}{3} = 57.73\ V$$

NOTE

During the ground-fault test, the set matching factor can be checked by comparing the operational measured values. The operational measured values contain the calculated zero sequence voltage $V_{0\,sec}$ and the measured residual voltage $V_{N\,sec}$. Proceed with the computation as follows:

$$\text{Matching ratio } \frac{Vph}{VN} = \frac{3 \cdot V_{0\,sec}}{V_{N\,sec}}$$

The Matching ratio Vph / VN parameter is significant for the following functions of the device:

- Overvoltage protection with zero-sequence/residual voltage
- Measured-value supervision
- Scaling of the fault and measured values

Parameter: VT connection

- Default setting (_:8911:104) VT connection = 3 ph-to-gnd volt. + VN

The parameter VT connection shows the connection type of the voltage transformer for the 3-phase voltage measuring point. The parameter can be found in the DIGSI 5 project tree under Name of the device → Parameter → Power-system data → Measuring point V 3-phase. You cannot change the connection type of the voltage transformer in the power system data.

You can change the connection type of the voltage transformer only under measuring point routing in DIGSI 5. Under Name of the device → Measuring point routing → Voltage measuring points, select the desired connection type under Connection type. The following types of connections are possible:

- 3 ph-to-gnd volt. + VN
- 3 ph-to-gnd voltages
- 3 ph-to-ph volt. + VN
- 3 ph-to-ph voltages
- 2 ph-to-ph volt. + VN
- 2 ph-to-ph voltages

Depending on the connection type selected, you must route the measured values to the terminals of the voltage measuring point in DIGSI 5. You can find connection examples for voltage transformers in chapter A.11 Connection Examples for Voltage Transformers. The connection examples provide assistance when selecting the type of connection.

Parameter: Inverted phases

- Default setting (_:8911:106) Inverted phases = none

The Inverted phases parameter is intended for special applications, for example, pumped storage hydro power plants (see chapter 6.22 Phase-Rotation Reversal). This default setting can be retained for power-system protection applications.

Parameter: Tracking

- Default setting (_:8911:111) Tracking = active

The Tracking parameter is used to determine whether the measuring channels of this measuring point shall be used to determine the sampling frequency.

The sampling frequency of the device is adjusted to the power frequency. The device selects a measuring channel, through which the sampling frequency is determined. Preferably, this should be a voltage measuring channel. If this validity of the signal is maintained (minimum level, frequency range). If these values are invalid, the device switches to another channel (etc.). Once switched to a current channel, the system automatically switches back to this channel if a voltage channel is valid again.

Parameter Value	Description
active	If the parameter Tracking = active has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. Note: Note that, during sampling-frequency tracking, the entire device is set to the determined sampling frequency. That is to say, all of the measuring point channels work with the determined main sampling frequency. Please keep this in mind when working with the device.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value inactive.

Parameter: Magnitude correction

- Default setting (_:3811:103) Magnitude correction = 1.000

With the Magnitude correction parameter, you adjust the amplitude (magnitude correction) for the voltage input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction can be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring voltage transformer). If a primary correction is not necessary, retain the default setting.

NOTE

The Magnitude correction parameter has nothing to do with the internal adjustment of the input circuit.

6.1.5 Application and Setting Notes for Measuring-Point Current 3-Phase (I-3ph)

The following example describes the settings for the current measuring points Measuring point I-3ph (Current 3-phase). The I-1ph measuring point has only a subset of the parameters described here. The description of the parameter is also valid for the I-1ph measuring point.

Parameter: CT connection

- Default setting (_:8881:115) CT connection = 3-phase + IN-separate

The parameter CT connection shows the connection type of the current transformer for the 3-phase current measuring point. The parameter can be found in the DIGSI 5 project tree under Name of the device

→ Parameter → Power-system data → Measuring point I 3-phase. You cannot change the connection type of the current transformer in the power system data.

You can change the connection type of the current transformer only under measuring point routing in DIGSI 5. Under Name of the device → Measuring point routing → Current measuring points, select the desired connection type under Connection type. The following types of connections are possible:

- 3-phase + IN-separate
- 3-phase + IN
- 3-phase
- 3-phase, 2 primary CT
- 3ph,2prim.CT + IN-sep

Depending on the connection type selected, you must route the measured values to the terminals of the current measuring point in DIGSI 5. You can find connection examples for current transformers in chapter A.10 Connection Examples for Current Transformers. The connection examples provide assistance when selecting the type of connection.

Parameter: Tracking

- Default setting (_:8881:127) Tracking = active

With the parameter Tracking, you specify whether you would like to work with the manual updating function of the sampling frequency.

Parameter Value	Description
active	If the parameter Tracking = active has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. Note: Please note that during the manual updating of the sampling frequency, the entire device is set to the defined sampling frequency, that is to say, all channels of all measuring points work with the determined main sampling frequency. Please keep this in mind when working with the device.
inactive	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value inactive.

Parameter: Rated primary current

- Default setting (_:8881:101) Rated primary current = 1000 A

With the Rated primary current parameter, the active rated primary current of the current transformer is set.

Parameter: Rated secondary current

- Default setting (_:8881:102) Rated secondary current = 1 A

With the Rated secondary current parameter, you set the active rated secondary current of the current transformer.

Parameter: Current range

- Default setting (_:8881:117) Current range = 100 x IR

The Current range parameter allows you to set the dynamic range for the current input. Please retain the default setting for power system protection applications. The setting value for the sensitive current input and the measuring current input is 1.6 x I_{rated}.

Parameter: Neutr.point in dir.of ref.obj

- Default setting (_:8881:116) Neutr.point in dir.of ref.obj = yes

The Neutr.point in dir.of ref.obj parameter is used to set the direction of the neutral point of the current transformer (see the following figure). Often, the neutral point of the current transformer is determined by the direction of the protected object (for example, in the direction of the line, cable, transformer). For this reason, the default setting of the parameter was defined as yes.

When switching the parameter, the direction of the phase currents and of the ground current IN or IN-separate is changed device-internally.

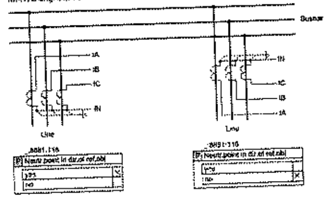


Figure 6-3 Polarity of Current Transformers

Parameter: Inverted phases

- Default setting (_:8881:114) Inverted phases = none

The Inverted phases parameter is intended for special applications, for example, pumped-storage hydro power plants (see chapter 6.42 Phase-Rotation Reversal). This default setting may be retained for power-system protection applications.

Parameter: CT error changeover

- Default setting (_:8881:107) CT error changeover = 5.00

The CT error changeover parameter is only relevant for the Line differential protection function. The CT error changeover parameter defines the transition range of the transformer fault from low to higher currents.

Parameter: CT error A

- Default setting (_:8881:108) CT error A = 5.0

The CT error A parameter considers the transformer fault at rated current plus a safety margin.

Parameter: CT error B

- Default setting (_:8881:109) CT error B = 15.0

The CT error B parameter considers the transformer fault at rated overcurrent factor plus a safety margin. It is the number preceding the letter P of the transformer data.

Parameter: Magnitude correction

- Default setting (_:3841:103) Magnitude correction = 1.000

When using the Magnitude correction parameter, you adjust the amplitude (amplitude correction) for the current input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the scaling value (for example, a high precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.

NOTE

The Magnitude correction parameter has nothing to do with the internal adjustment of the input circuit.

Note Regarding Routable Data

Indications for the current rotating field and the information pertaining to the manual updating can be found in Information routing under Power-system data → General in DIGSI 5. The indication Freq.out of oper.range means that the frequency operating range has been exceeded. Either the frequency is out of range (10 Hz to 80 Hz) or the input signals are too small for a manual update. Should the condition occur, the system switches the update frequency to a sampling rate that corresponds to the rated frequency.

Furthermore, there are 2 additional measured frequency values available. The measured value f sys displays the current system frequency, and the measured value f track displays the sampling frequency currently set. Siemens recommends routing both measured values as fault-recording channel.

6.1.6 Application and Setting Notes for Line Differential Protection Settings

NOTE

The following parameters are only important for the Line differential protection function. These parameters can be found in DIGSI 5 project tree under Device name (for example, 7SL86) → Settings → Power-system data under Measuring point I-3ph.

Current-Transformer Characteristic Curve

The basic principle of the Differential-protection function assumes that all currents flowing into a healthy protected object add up to 0. If the sets of current transformers indicate different transformation errors at the line ends in the overcurrent range, the secondarily measured sum of the currents may reach a significant magnitude during external short circuits and the high flow of current resulting from this fact. This may simulate an internal short circuit.

The adaptive stabilization method of the line differential protection considers the errors between during current-transformer transmission errors. For this reason, the measuring error must be known with regard to the value of the current transformed by the current transformer. To do this, set the characteristic data of the current transformer and the secondary circuits. In many cases the default setting may be maintained. It considers the data of the most unfavorable protection current transformer. By using the following settings, the Line differential protection function approximates the characteristic curve of the transformer fault and calculates the stabilization value.

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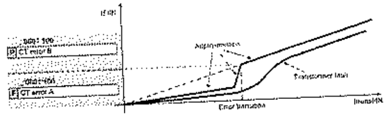

Figure 6-4 Transmission Behavior of the Current Transformer

Parameter: CT error changeover

- Default setting (_:8881:107) CT error changeover = 2.50

The CT error changeover parameter defines the transition range of the transformer fault from low to higher currents.

$$CT\ error\ changeover = \frac{n'}{n} = \frac{P_N + P_i}{P' + P_i}$$

with

n'	Operational overcurrent factor (effective overcurrent factor)
n	Rated overcurrent factor of the current transformer (letter following the letter 'P')
P_N	Rated burden of the current transformer at rated current in [VA]
P_i	Internal current transformer burden at rated current in [VA]
P'	Actually connected burden (devices and secondary connection cables) at rated current in [VA]

The rated overcurrent factor n and the rated power P_N of the current transformer can be found on the name plate of the current transformer. These values refer to the specified conditions (rated current, rated burden).

EXAMPLE:

Current transformer per VDE 0414/Part 1 or IEC 60044

Current transformer 10P10; 30 VA → n = 10; P_N = 30 VA

Current transformer 10P20; 20 VA → n = 20; P_N = 20 VA

The operational overcurrent factor n' is the result of the rated data and the actual secondary burden P'. Under normal circumstances, the internal burden of the current transformer is documented in the test protocol. If this value is unknown, the internal burden Pi can be approximated and determined from the DC resistance R_i of the secondary winding:

$P_i = R_i \cdot I^2_{sec}$

You can find the Siemens setting recommendation in Table 6-1.

Parameter: CT error A

- Default setting (_:8881:108) CT error A = 5.0

The CT error A parameter considers the transformer fault at rated current plus a safety margin. According to VDE 0414/Part 1 or IEC 60044, at a primary rated current I_1, the CT error A is equal to the measured current deviation.

Example:

Current transformer 5P: 1 %
Current transformer 10P: 5 %

You can find the Siemens setting recommendation in Table 6-1.

Parameter: CT error B

- Default setting (_:8881:109) CT error B = 15.0

The CT error B parameter considers the transformer fault during rated overcurrent factor in addition to the safety margin. It is the number preceding the letter P of the transformer data.

You can find the Siemens setting recommendation in Table 6-1.

Setting Recommendations for General Protection Current Transformers

The following table lists general protection current transformers with characteristic data, including associated setting recommendations:

Table 6-1 Setting Recommendations for Current Transformer Data

Transformer Class	Standard	Rated Current Error		Rated Overcurrent Factor Error	Setting Recommendations for Settings		
		Ratio	Angle		CT error changeover	CT error A	CT error B
					1.50	3.0 %	10.0 %
5P	IEC 60044-1	1.0%	± 60 min	≤ 5 %	1.50	5.0 %	15.0 %
10P		3.0%		≤ 10 %	1.50	1.0 %	10.0 %
TPX		0.5%	± 30 min	ε ≤ 10 %	1.50	3.0 %	15.0 %
TPY		1.0%	± 30 min	ε ≤ 10 %	1.50	6.0 %	20.0 %
TPZ		1.0%	180 min ± 18 min	ε ≤ 10 % (only I ≈)			
					1.50	3.0 %	10.0 %
PX	IEC 60044-1 BS: Class X						
					1.50	5.0 %	15.0 %
C100 to C800	ANSI						

EXAMPLE:

Current transformer	5P10; 20 VA
Ratio R_i	600 A/5 A
Inherent burden	2 VA
Secondary lines	4 mm² copper (Cu)
Specific resistance of Cu	0.0175 Ω mm²/m
Length	20 m
I_{sec}	5 A
Burden at 5 A	0.3 VA

The resistance of the secondary lines is calculated as follows:

$$R_L = 2 \cdot 0.0175 \frac{\Omega mm^2}{m} \cdot \frac{20\ m}{4\ mm^2} = 0.175\ \Omega$$

The worst-case scenario has been assumed for this calculation, whereby during a 1-pole error the current flows back and forth across the secondary lines (factor 2). This follows that the power at a rated current of I_{sec} = 5 A can be calculated as:

$P_L = 0.175\ \Omega \cdot (5\ A)^2 = 4.375\ VA$

The entire connected burden comprises the burden of the supply lines and the burden of the device, and is calculated as follows:

$P' = 4.375\ VA + 0.3\ VA = 4.675\ VA$

The ratio of the overcurrent factors is calculated as follows:

$$CT\ error\ changeover = \frac{n'}{n} = \frac{P_N + P_i}{P' + P_i} = \frac{20\ VA + 2\ VA}{4.675\ VA + 2\ VA} = 3.30$$

According to Table 6-1, Siemens recommends the following setting values:

CT error changeover = 1.50
CT error A = 3.0 %
CT error B = 10.0 %

Transformer with Voltage Control

If the power transformer with voltage control is within the protection range, please observe the following: A differential current occurs already during stationary operation. This differential current depends on the current and the position of the tap changer. This is a current-proportional error. For this reason, it should be dealt with as an additional current transformer error.

Calculate the max. deviation along the limits of the control range (referring to the mean current of the control range). Add the max. deviation to the calculated transformer faults A and B. Implement this correction only for the end that is facing the controlling side of the transformer.

EXAMPLE:

For a transformer YNd5, 35 MVA, 110 kV/20 kV, Y-side controlled ± 10 %

This results in the following values:

Rated current at rated voltage = 184 A
Rated current at V_{max} = 10% V_{rated} = 167 A
Rated current at V_{min} = 10% V_{rated} = 202 A

For the controlled side of the transformer the following mean current is determined:

$$I_{mean} = \frac{I_{min} + I_{max}}{2} = \frac{167\ A + 202\ A}{2} = 184.5\ A$$

The max. deviation of this mean current is:

$$\delta_{max} = \frac{I_{max} - I_{mean}}{I_{mean}} = \frac{202\ A - 184.5\ A}{184.5\ A} = 0.095 = 9.5\%$$

Add this max. deviation to the transformer errors CT error A and CT error B determined as described above. Ensure that this deviation due to voltage control relates to the mean current at rated apparent power and not to the rated current at the rated voltage.

6.1.7 Settings

General Information

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Phase sequence		• ABC • ACB	ABC

Measuring Point I-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:2311:102	General:Rated secondary current		• 1 A • 5 A	1 A
_:2311:103	General:Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR • 50 x IR	100 x IR
_:2311:104	General:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:2311:116	General:Term. 1,3,5,7 in dir. of obj.		• no • yes	yes
_:2311:105	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring point ID		0 to 100	0
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• IA • IB • IC • IN • INsens • Ix	

Measuring Point I-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8881:115	CT 3-phase:CT connection		• not assigned • 3-phase + IN • 3-phase • 3-phase + IN-separate • 3-phase, 2 primary CT • 3ph,2prim.CT + IN-sep	3-phase + IN
_:8881:127	CT 3-phase:Tracking		• inactive • active	active
_:8881:130	CT 3-phase:Measuring-point ID		0 to 100	0
CT phases				
_:8881:101	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:102	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:117	CT 3-phase:Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:118	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:8881:116	CT 3-phase:Neutr.point in dir.of ref.obj		• no • yes	yes
_:8881:114	CT 3-phase:Inverted phases		• none • AC • BC • AB • All	none
_:8881:107	CT 3-phase:CT error changeover		1.00 to 10.00	1.50
_:8881:108	CT 3-phase:CT error A		0.5 % to 50.0 %	5.0 %
_:8881:109	CT 3-phase:CT error B		0.5 % to 50.0 %	15.0 %
CT 3Y				
_:8881:104	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:105	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:119	CT 3-phase:Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:120	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
CT 3ND				
_:8881:106	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A

Addr.	Parameter	C	Setting Options	Default Setting
_:8881:111	CT 3-phase:Rated secondary current		1 A to 5 A	1 A
_:8881:121	CT 3-phase:Current range		• 1.6 x IR • 8 x IR • 20 x IR • 100 x IR • 50 x IR	1.6 x IR
_:8881:132	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• IA • IB • IC • IN • INsens • Ix	
CT 2				
_:3842:103	CT 2:Magnitude correction		0.010 to 10.000	1.000
_:3842:117	CT 2:Phase		• IA • IB • IC • IN • INsens • Ix	
CT 3				
_:3843:103	CT 3:Magnitude correction		0.010 to 10.000	1.000
_:3843:117	CT 3:Phase		• IA • IB • IC • IN • INsens • Ix	
CT 4				
_:3844:103	CT 4:Magnitude correction		0.010 to 10.000	1.000
_:3844:117	CT 4:Phase		• IA • IB • IC • IN • INsens • Ix	
Supv. balan. I				
_:2491:1	Supv. balan. I:Mode		• off • on • test	off

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Addr.	Parameter	C	Setting Options	Default Setting
_:2491:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:2491:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:2491:6	Supv. balan. I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. ph. seq. I				
_:2551:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:2551:6	Supv. ph.seq.I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. sum I				
_:2431:1	Supv. sum I:Mode		• off • on • test	off
_:2431:101	Supv. sum I:Threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2431:102	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:2431:6	Supv. sum I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. ADC sum I				
_:2401:1	Supv. ADC sum I:Mode		• off • on • test	off

Measuring Point V-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary voltage		0.200 kV to 1200.000 kV	400.000 kV
_:2311:102	General:Rated secondary voltage		80 V to 340 V	100 V
_:2311:103	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
_:3811:108	VT 1:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB •	
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

Measuring Point V-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8911:101	VT 3-phase:Rated primary voltage		0.200 kV to 1200.000 kV	400.000 kV
_:8911:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:8911:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:8911:104	VT 3-phase:VT connection		• not assigned • 3 ph-to-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages	3 ph-to-gnd volt. + VN
_:8911:106	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8911:111	VT 3-phase:Tracking		• inactive • active	active
_:8911:130	VT 3-phase:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000
_:3811:108	VT 1:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB	
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647

Addr.	Parameter	C	Setting Options	Default Setting
VT 2				
_:3812:103	VT 2:Magnitude correction		0.010 to 10.000	1.000
_:3812:108	VT 2:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB	
_:3812:107	VT 2:Sequence number device		1 to 2147483647	2147483647
VT 3				
_:3813:103	VT 3:Magnitude correction		0.010 to 10.000	1.000
_:3813:108	VT 3:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB •	
_:3813:107	VT 3:Sequence number device		1 to 2147483647	2147483647
VT 4				
_:3814:103	VT 4:Magnitude correction		0.010 to 10.000	1.000
_:3814:108	VT 4:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB •	
_:3814:107	VT 4:Sequence number device		1 to 2147483647	2147483647
Supv. balan. V				
_:2521:1	Supv. balan. V:Mode		• off • on • test	off
_:2521:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:2521:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75
_:2521:6	Supv. balan. V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph. seq. V				
_:2581:1	Supv. ph.seq.V:Mode		• off • on • test	off
_:2581:6	Supv. ph.seq.V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. sum V				
_:2461:1	Supv. sum V:Mode		• off • on • test	off
_:2461:3	Supv. sum V:Threshold		0.300 V to 170.000 V	25.000 V
_:2461:6	Supv. sum V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

6.1.8 Information List

General

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Ph-rotation reversal	SPS	I
_:2311:501	General:>Invert Phases	SPS	I
General			
_:2311:319	General:Phase sequence ABC	SPS	O
_:2311:320	General:Phase sequence ACB	SPS	O
_:2311:321	General:Freq.out of oper.range	SPS	O
_:2311:322	General:f sys	MV	O
_:2311:323	General:f track	MV	O

Measuring Point I-1ph

No.	Information	Data Class (Type)	Type
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O

Measuring Point I-3ph

No.	Information	Data Class (Type)	Type
General			
_:8881:319	CT 3-phase:Phases AB inverted	SPS	O
_:8881:320	CT 3-phase:Phases BC inverted	SPS	O
_:8881:321	CT 3-phase:Phases AC inverted	SPS	O
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O

No.	Information	Data Class (Type)	Type
CT 2			
_:3842:300	CT 2:Sampled val. current	SAV	O
CT 3			
_:3843:300	CT 3:Sampled val. current	SAV	O
CT 4			
_:3844:300	CT 4:Sampled val. current	SAV	O
Supv. balan. I			
_:2491:82	Supv. balan. I:>Block function	SPS	I
_:2491:54	Supv. balan. I:Inactive	SPS	O
_:2491:52	Supv. balan. I:Behavior	ENS	O
_:2491:53	Supv. balan. I:Health	ENS	O
_:2491:71	Supv. balan. I:Failure	SPS	O
Supv. ph. seq. I			
_:2551:82	Supv. ph.seq.I:>Block function	SPS	I
_:2551:54	Supv. ph.seq.I:Inactive	SPS	O
_:2551:52	Supv. ph.seq.I:Behavior	ENS	O
_:2551:53	Supv. ph.seq.I:Health	ENS	O
_:2551:71	Supv. ph.seq.I:Failure	SPS	O
Supv. sum I			
_:2431:82	Supv. sum I:>Block function	SPS	I
_:2431:54	Supv. sum I:Inactive	SPS	O
_:2431:52	Supv. sum I:Behavior	ENS	O
_:2431:53	Supv. sum I:Health	ENS	O
_:2431:71	Supv. sum I:Failure	SPS	O
Supv. ADC sum I			
_:2401:82	Supv. ADC sum I:>Block function	SPS	I
_:2401:54	Supv. ADC sum I:Inactive	SPS	O
_:2401:52	Supv. ADC sum I:Behavior	ENS	O
_:2401:53	Supv. ADC sum I:Health	ENS	O
_:2401:71	Supv. ADC sum I:Failure	SPS	O

Measuring Point V-1ph

No.	Information	Data Class (Type)	Type
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
VT miniatureCB			
_:2641:500	VT miniatureCB:>Open	SPS	I

Measuring Point V-3ph

No.	Information	Data Class (Type)	Type
General			
_:8911:315	VT 3-phase:Phases AB inverted	SPS	O
_:8911:316	VT 3-phase:Phases BC inverted	SPS	O
_:8911:317	VT 3-phase:Phases AC inverted	SPS	O

No.	Information	Data Class (Type)	Type
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
VT 2			
_:3812:300	VT 2:Sampled val. voltage	SAV	O
VT 3			
_:3813:300	VT 3:Sampled val. voltage	SAV	O
VT 4			
_:3814:300	VT 4:Sampled val. voltage	SAV	O
Supv. balan. V			
_:2521:82	Supv. balan. V:>Block function	SPS	I
_:2521:54	Supv. balan. V:Inactive	SPS	O
_:2521:52	Supv. balan. V:Behavior	ENS	O
_:2521:53	Supv. balan. V:Health	ENS	O
_:2521:71	Supv. balan. V:Failure	SPS	O
Supv. ph. seq. V			
_:2581:82	Supv. ph.seq.V:>Block function	SPS	I
_:2581:54	Supv. ph.seq.V:Inactive	SPS	O
_:2581:52	Supv. ph.seq.V:Behavior	ENS	O
_:2581:53	Supv. ph.seq.V:Health	ENS	O
_:2581:71	Supv. ph.seq.V:Failure	SPS	O
Supv. sum V			
_:2461:82	Supv. sum V:>Block function	SPS	I
_:2461:54	Supv. sum V:Inactive	SPS	O
_:2461:52	Supv. sum V:Behavior	ENS	O
_:2461:53	Supv. sum V:Health	ENS	O
_:2461:71	Supv. sum V:Failure	SPS	O
VT miniatureCB			
_:2641:500	VT miniatureCB:>Open	SPS	I

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6.2 Transformer Differential Protection

6.2.1 Overview of Functions

The Transformer differential protection function (ANSI 87T):

- Detects ground faults and multiphase short circuits in transformers, reactors, short lines, as well as generators and motors
- Is appropriate for block protection for generator-transformer blocks, transformer-reactor combinations or transformer-neutral reactors
- Has available the necessary stabilization methods in the event of connection and overexcitation processes
- Is stable in the event of external short-circuits with current transformer saturation through intelligent saturation recognition methods
- Triggers safely in the case of internal high-current faults through an additional high-current stage

Depending on the basic type of the device selected, can protect different system configurations. In the simplest implementation (7UT82), this is a two-winding transformer. The 7UT85 protects a two-winding transformer or an auto transformer. The 7UT86 processes 3 sides or 3 measuring points. In a function group, 2 differential protection functions can run in parallel for auto transformer applications. In the maximum implementation (7UT87), up to 5 sides or a maximum of 7 measuring points can be processed. Furthermore, the 7UT87 can process 2 function groups of Transformer differential protection.

6.2.2 Structure of the Function

The function Transformer differential protection is used in the protection function group Transformer or Auto Transformer. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group. The Transformer differential protection function consists of the tripping stages IDiff and IDiff fast. The tripping stages can be blocked. In addition you can switch the tripping stages on and off.

The following actions are performed in the Transformer side function group:

- Accept side related protection settings
- Perform side-related calculations
- Send all data (setting values, included currents) to the function group Transformer
- Accept necessary settings for adapting differential protection to the current tap changer setting

Side related protection functions can run in the function group Transformer side, for example, restricted ground-fault protection, overload protection, overcurrent protection.

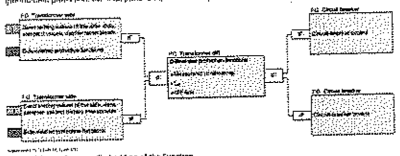

Figure 6-5 Structure/Embedding of the Function

6.2.3 Functional Description

6.2.3.1 Basic Principle of Differential Protection

Differential protection is based on a current comparison (on a nodal representation according to Kirchhoff, however, accounting for the current ratio of the transformer). When comparing the current, use is made of the fact that a protected object uses the same current I on a non-faulty operating state on both sides (dotted in Figure 6-6). This current flows into the range being examined on one side and leaves it again on the other side. A current differential is a sure indication of a fault within the protected object. The calculation of the difference is determined through the current direction definition. The current direction is defined as positive to the protected object. The current difference results from the vector addition of the currents.

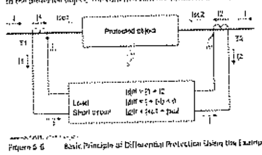

Figure 6-6 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in Chapter 6.2.3.6 Differential Protection Function Stages.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers W1 and W2 (Figure 6-6) a corresponding differential current I_{diff} occurs. When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current (I_{rest}) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The definition for 2 measuring points is:

A trip or differential current is

$I_{diff} = |\underline{I}_1 + \underline{I}_2|$

as well as a restraint current of

$I_{rest} = Max(|\underline{I}_1|; |\underline{I}_2|)$

For more than 2 measuring points this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different feeding behavior for internal short circuits.

$I_{rest} = Max(|\underline{I}_1|; |\underline{I}_2|; ...; |\underline{I}_n|)$

To clarify the effect 3 important operating states are observed with ideal and adapted measurands.

- Through fault current in healthy operation or external short circuit:
  $\underline{I}_1$ flows into the protection range, $\underline{I}_2$ flows out of the protection range, that is, negative compared with the prefix definition, then $\underline{I}_2 = -\underline{I}_1$;
  in addition $|\underline{I}_2| = |\underline{I}_1|$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - \underline{I}_1| = 0$
  $I_{rest} = Max(|\underline{I}_1|; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$
  No tripping quantity ($I_{diff} = 0$); the stabilization (I_{rest}) corresponds to the flowing current.

- Internal short circuit, fed from both sides with equal amount of currents, for example:
  then $\underline{I}_2 = \underline{I}_1$, in addition $|\underline{I}_2| = |\underline{I}_1|$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + \underline{I}_1| = 2 \cdot |\underline{I}_1|$
  $I_{rest} = Max(|\underline{I}_1|; |\underline{I}_2|) = |\underline{I}_1| = |\underline{I}_2|$
  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the restraining quantity (I_{rest}).
- Internal short circuit, fed only from one side:
  Then $\underline{I}_2 = 0$
  $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + 0| = |\underline{I}_1|$
  $I_{rest} = Max(|\underline{I}_1|; |\underline{I}_2|) = |\underline{I}_1|$
  The tripping quantity (I_{diff}) and the restraining quantity (I_{rest}) are the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with Figure 6-7 there are 2 typical scenarios:

- High-current, external short circuit
  First, the current on both sides is transmitted and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current I_{rest} drops out. Once the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.
- Low-current, external short circuit
  Current transformers can also become saturated through the large direct current time constant (switching of transformers, motors), but small currents flowing. This manifests itself as a phase angle rotation of the current. Exceeding the characteristic curve in a non stabilized area is possible.

Intelligent saturation detection methods capture this state and lead to a temporarily limited blocking of the Differential protection function.

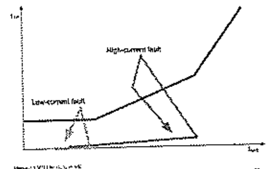

Figure 6-7 Principle Current Course at External Short Circuit and Temporary Current Transformer Saturation on One Side

Inrush Current and Overexcitation Stabilization

When a transformer is switched on, an inrush current with a DC component flows, since the flow cannot change itself erratically. The inrush current develops in all phases and appears immediately as differential

current. The direct-current time constant can amount to several seconds with large transformers. The following figure shows a typical situation.

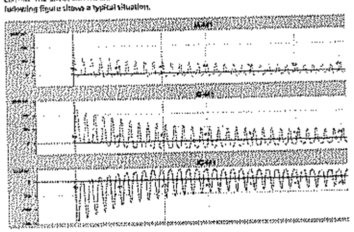

Figure 6-8 Typical Inrush Current Curve

If a transformer is operated with too high of a voltage, it can be modulated up into the non-linear part of the magnetization characteristic curve. An increased magnetizing current results, which manifests itself as an increased differential current and can lead to an overfunction.

For this reason, additional functions are required which block the differential protection with closure and overexcitation processes.

6.2.3.2 Logic of the Function

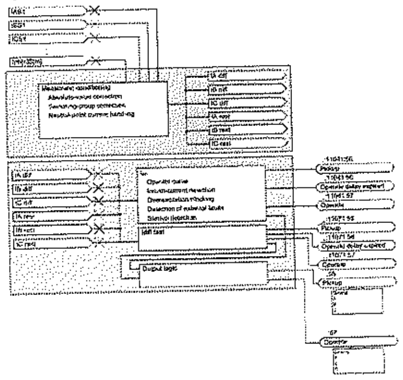

Figure 6-9 Logic Diagram of the Transformer Differential Protection Function

In the following, the essential components of differential protection are described in detail. The two-winding implementation, the basic structure of which shows Figure 6-10, serves as an example. The connection is between the phase current transformers and the neutral point current transformer. Additionally, both relevant function groups for differential protection are represented.

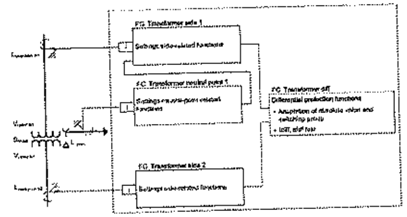

Figure 6-10 Connection and Basic Structure for the Example of the Two-Winding Transformer YdS

6.2.3.3 Measurand Processing

Absolute-Value Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection function processes 20 sampled values per period. In addition, the sampled values tracked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 80 Hz).

The Idiff-fast stage works on non-frequency tracked values and thus, implements fast operate times with the frequencies.

The absolute value is adapted via the following formula:

$i_{A,B,C}^{*} = k \cdot i_{A,B,C}$

$\text{with } k = \frac{I_{rated,CT,prim}}{I_{rated,obj,side}} = \frac{I_{rated,CT,prim}}{\frac{S_{rated,ref}}{V_{rated,side} \cdot \sqrt{3}}}$

$i_{A,B,C}^{*}$	Adapted instantaneous value per phase (x = A, B, C)
$i_{A,B,C}$	Instantaneous value per phase (x = A, B, C)
k	Correction value per measuring point
$I_{rated,CT,prim}$	Primary transformer rated current per measuring point
$S_{rated,ref}$	Reference power (maximum rated apparent power of the protected object)
$V_{rated,side}$	Rated voltage of the respective side (measuring point) of the protected object

NOTE

The largest power is used as reference winding with a multi winding transformer. If several windings have the same absolute value of power, then, the highest current winding is selected as the reference winding. The absolute value of the neutral-point transformer is also adapted according to the previous formula. In this case, the absolute value should be adapted to the side with the greatest power.

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Tap Changer Adaptation

If a tap changer is present and is allocated to a transformer side, the side currents are also adapted to the current tap changer position. In order to activate this functionality, the settings must be made in the Transformer side function group. The settings Tap changer, Basic position and Volt. diff. step are in the Application and Setting Instructions. (Setting Parameters) A more detailed explanation of tap changers.

Make the stage setting that corresponds to the rated voltage and the setting for the stage voltage. With these settings, an adjustment factor is calculated for each existing tap changer position.

$$k_{TC} = k_{Basic\,correction} \cdot \left(1 + \frac{(Pos_{TC} - BasPos) \cdot \Delta V}{V_{rated}}\right)$$

with

Pos_{TC}	Existing tap changer position
BasPos	Basic position of the tap changer
ΔV	Voltage difference of a stage
V_{rated}	Rated voltage
$k_{Basic\,correction}$	Corresponds to the correcting value for each measurement point

When the running contact of the motor drive is activated by the tap changer, the previous stage remains active until the running contact signals the end of the motor run.

If capture of the current tap changer position malfunctions, a higher operate curve takes effect. In this case, 2 measures become effective:

1. Calculation of an average adjustment factor

$$k_{ref} = k_{Basic\,correction} \cdot \frac{V_{ref}}{V_{rated}}$$

$$V_{ref} = \frac{2}{\frac{1}{V_{min}} + \frac{1}{V_{max}}}$$

2. Non-sensitive setting of the operate curve with factor k_{NS}

$$k_{NS} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

Vector-Group Correction

The vector groups of the transformer sides arise from the different side-wise coupling of the transformer windings to the transformer core as well as its configuration (Y, D, Z). Therefore, the measured currents cannot be used directly for summation. The vector-group correction replicates the magnetic coupling of the transformer coils and makes the measured currents comparable. The correction occurs such that each side is converted to vector group 0. Since you are in the 3-phase system, the conversion occurs via matrices which are stored for the respective vector-group type. The general description is given in the following formula. In the same calculation step, the absolute value is corrected.

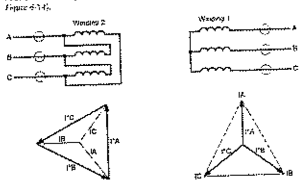
$$\begin{bmatrix} i_A^* \\ i_B^* \\ i_C^* \end{bmatrix} = k \cdot M_{SO} \cdot \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix}$$

with

$i_{x,k}^*$	Adapted instantaneous value per phase (x = A, B, C)
$i_{x,k}$	Instantaneous value per phase (x = A, B, C)
k	Amount correction per measuring point
M_{SO}	Correction matrix

The following example (Figure 6-11) shows the conversion. The neutral point is insulated against ground such that no residual current (short-circuit current) can arise in case of an external fault and can therefore not cause a faulty measurement.

In the example, the currents are processed directly. On the delta side, the conversion takes place with a vector group 0. If the measured residual current is also taken into account while using this matrix with the present neutral marker, a higher sensitivity with regard to the usual elimination matrix can be attained (see Figure 6-11).



$$\begin{bmatrix} I_A^* \\ I_B^* \\ I_C^* \end{bmatrix} = \frac{1}{3} \cdot \begin{bmatrix} 1-\sqrt{3} & 1 & 1+\sqrt{3} \\ 1+\sqrt{3} & 1-\sqrt{3} & 1 \\ 1 & 1+\sqrt{3} & 1-\sqrt{3} \end{bmatrix} \cdot \begin{bmatrix} IA \\ IB \\ IC \end{bmatrix} \qquad \begin{bmatrix} I_A^* \\ I_B^* \\ I_C^* \end{bmatrix} = 1 \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} IA \\ IB \\ IC \end{bmatrix}$$

Figure 6-11 Vector-Group Adaptation with the Example of Yd5 without Accounting for the Amount Adaptation

6.2.3.4 Neutral-Point Current Treatment

Considering the Neutral-Point Current

If the neutral point of a transformer winding is grounded, a current can also flow into the protection range in the case of a ground fault via this neutral point. For a complete summation, this current must be included. In Figure 6-12 an outflowing zero-sequence current, for example, a fault occurs on the right side in the phase currents ($I_L = 3I_0$). This corresponds to the current flowing into the neutral point ($I_Y = 3I_0$), such that the currents enter into the sum.

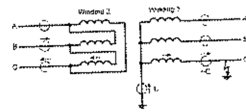


Figure 6-12 Vector-Group Adaptation with the Example of Yd5

The complete matrix equation for the grounded side (Y side) with inclusion of all currents flowing in is, in this case:

$$\begin{bmatrix} I_A^* \\ I_B^* \\ I_C^* \end{bmatrix} = 1 \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} + \frac{1}{3} \cdot \begin{bmatrix} I_Y \\ I_Y \\ I_Y \end{bmatrix}$$

I_Y corresponds to $-3I_0$ with current flowing. With a ground fault within the transformer area, the zero-sequence current goes in as a result ($I_Y = 1/3\, I_Y$). With a ground fault outside, however, the zero-sequence current falls out, since the zero-sequence current measured on the terminals $3I_0 = (I_A + I_B + I_C)$ (negative here) removes the neutral-point current I_Y. Given this, nearly complete sensitivity is guaranteed for internal ground faults, while the zero-sequence current is automatically eliminated in case of an external ground fault.

If the following conditions are satisfied, the neutral-point current is accounted for:

- In the function group Transformer side, the parameter Neutral point = grounded is set.
- The function group Transformer neutral point is connected with the measuring point and the function group Transformer side (see Figure 6-12).
- In the function group Transformer, the parameter Meas. gnd. current side 1 = yes is set.

You can attain increased sensitivity for ground faults in the protection range by using the restricted ground-fault protection (see chapter 6.4 Restricted Ground-Fault Protection).

> **NOTE**
>
> In order to enable the proper function of the differential protection, the neutral-point transformer must be designed correspondingly strong (almost saturation free). Insofar 1-pole short circuits can lead to too high neutral-point currents. The harmonics resulting from a saturation can lead to a blocking of the tripping by the inrush-current detection. In addition a saturation when tripping can result in an unambiguous fault situation, that is unaffected phases also signal a tripping.

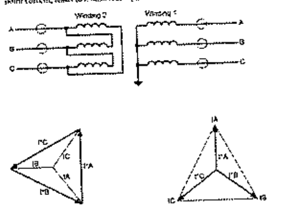
Neutral-Point Current is not Measured

Often the neutral-point current is not accessible, however, or is not coupled into the differential protection. Then, in accordance with Figure 6-11/Figure 6-12, a complete summation across all currents flowing into the protected object is not possible, since I_Y does not go in. So that the zero-sequence current in the phase currents ($I_L = -3I_0$) does not lead to a faulty differential current, it must be eliminated.

The Figure 6-13 shows an example of the vector group YNd5 with grounded neutral point on the Y side. On the left side (delta side) of the figure, the zero-sequence current drops out automatically through formation of the differential current. Even in the transformer itself, no zero-sequence current is possible outside of the delta winding. If the neutral-point current cannot be measured, the zero-sequence current on the right side must be eliminated. This results from the matrix equation, for example, for:

$$I^*_A = 1/3\,(2\,I_A - 1\,I_B - 1\,I_C) = 1/3\,(3\,I_A - (I_A + I_B + I_C)) = 1/3\,(3\,I_A - 3\,I_0) = (I_A - I_0)$$

By eliminating the zero-sequence current, fault currents are rendered harmless without special external measures. The fault currents also flow as a consequence of grounding in the protection range (transformer neutral point or neutral reactor) with ground faults in the power system via the current transformers. In Figure 6-13 a zero-sequence current arises on the right side during an external fault, for example, but not on the left side. A comparison of the currents without zero-sequence current elimination and without inclusion of the neutral-point current, leads to a false result (differential current despite fault being external).



$$\begin{bmatrix} I_A^* \\ I_B^* \\ I_C^* \end{bmatrix} = \frac{1}{3} \cdot \begin{bmatrix} 1-\sqrt{3} & 1 & 1+\sqrt{3} \\ 1+\sqrt{3} & 1-\sqrt{3} & 1 \\ 1 & 1+\sqrt{3} & 1-\sqrt{3} \end{bmatrix} \cdot \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} \qquad \begin{bmatrix} I_A^* \\ I_B^* \\ I_C^* \end{bmatrix} = \frac{1}{3} \cdot \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix} \cdot \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix}$$

Figure 6-13 Vector-Group Adaptation for the Example of YNd5

Figure 6-14 shows an example of a ground fault on a delta side outside of the protection range with a neutral reactor (zigzag reactor) within the protection range. Here, too, a zero-sequence current arises on the right side, but not on the left side. If the neutral reactor is outside of the protection range (current transformer between power transformer and neutral reactor), then the zero-sequence current is harmless, since it does not flow through a measuring point (current transformer).

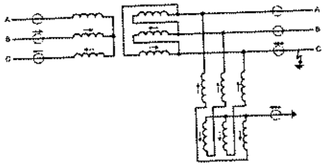


Figure 6-14 Example of Ground Fault Outside of the Grounding Transformer within the Protection Range with Current Distribution

Zero-sequence current elimination has the disadvantage that the differential protection is less sensitive with ground faults in the protection range of the grounded side around the zero-sequence current. Since the zero-sequence current makes up 1/3 of the short-circuit current, a sensitivity of 2/3 is achieved. If there is no neutral-point grounding present in the protection range or the neutral-point current can be captured (Figure 6-12), the zero-sequence current elimination is unnecessary (see Figure 6-11). In order to not recognize an electric breakdown as an internal fault with a connected surge arrester on the neutral point you must make do without this advantage.

If, in the function group Transformer side, the parameter Neutral point = grounded is set and no neutral-point current is coupled into the function group (see Figure 6-10), then the zero-sequence current elimination always takes place. If a neutral-point current is coupled into the function group Transformer side (for example, for the restricted ground-fault protection) and in the function group Transformer, the parameter Meas. gnd. current side 1 = no is present, then a zero-sequence current elimination is also performed. If Neutral point = isolated is set, the phase currents are processed directly, without the zero-sequence currents being taken into account. If nothing is connected to the neutral point, make this setting.

6.2.3.5 Special Aspects of an Auto Transformer

In order to make the resulting currents for the differential protection comparable, all currents refer to the auto winding (= side of the protected object) with the largest rated apparent power. This is designated rated power of the protected object. If the highest rated apparent power occurs multiple times, the side with the higher rated current is selected as the reference side.

With auto transformers, there is only the vector group for the auto transformer winding YNOd0 (Figure 6-15). Neutral-point grounding affects all auto-transformer windings connected to the parts of the electrical power system (upper-voltage and undervoltage). With a ground fault, coupling between the 2 parts of the electrical power system occurs via the common neutral point grounding.

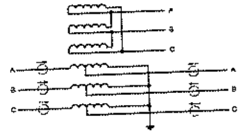


Figure 6-15 Auto Transformer with Grounded Neutral Point

Here, too, the neutral-point current I_{sp} is necessary for a complete treatment of all currents flowing into the protected area. If the neutral point is not accessible, the residual current from the two phase currents must be eliminated. This means that the matrix with the residual current elimination is used on both sides. As with separated windings, differential protection with ground faults in the protection range is then reduced in sensitivity to 2/3 of the fault current. The residual current amounts to 1/3 of the short-circuit current.

If the neutral-point current is accessible and connected to the device, all currents flowing into the protection range are available. The residual current in the phases then enters into the sum with outside-lying ground faults through the neutral-point current. With an inward-lying ground fault, the full sensitivity of differential protection is thereby guaranteed.

In order to attain an even higher sensitivity with ground faults in the protection range with the help of the neutral-point current, you can use the restricted ground-fault protection.

If, in the case of an auto transformer, three 1-phase auto transformers are interconnected, it is possible to attain a good ground fault sensitivity. With this arrangement, the 1-phase ground fault is the most likely fault. Short circuits between the phases are excluded due to spatial separation. Here you can create current differential protection through each winding which captures the sum of all currents flowing to the node (the winding).

The requirements for the case that you configure an auto transformer with a 1-phase current connection for the grounding side and set the parameter (_:2311:100) Protection Mode = Current node.

> **NOTE**
>
> The differential protection function records on stabilizing winding with Current node. A stabilizing winding must be additionally protected.

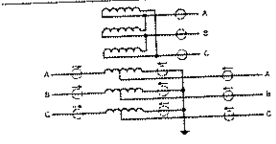


Figure 6-16 Auto Transformer Bank with Current Transformer in the Neutral Point Feed

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6.2.3.6 Differential Protection Function (I-DIFF)

A differential current per phase based on the instantaneous value variables is calculated from the measured currents (see section Measuring Processing). The direction of current flow is defined as in the protected object as positive. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length = 1 period (20 samples)) as well.

If the neutral-point current is connected, it is accounted for in the differential current as well as in the restraint current. This state of affairs is not represented for the reason of simplification in the following formulas. The currents of that measuring point whose RMS value is the largest are used as restraint current. Residual or zero-sequence currents are also accounted for. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation, the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

NOTE

Differential protection does not work with sensitive ground-current transformers. Since sensitive transformers can go into saturation too quickly, false differential currents arise.

$$I_{diff,phx} = \sum_{m=1}^{N} I_{phx,m} \rightarrow I_{diff,phx} = FIR(I_{diff,phx})$$

$$I_{phx,RMS} = \sqrt{\frac{1}{n}\sum_{k=1}^{n} i^2_{phx,RMS}(k)}$$

$$I_{restr,phx} = \underset{m=1}{\overset{N}{MAX}} I_{phx,RMS}$$

with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)
FIR	Fourier filter
MAX	Maximum value determination

Pickup Characteristic

The Figure 6-17 shows the pickup characteristic of the I-DIFF. The characteristic curve branch a represents the sensitivity threshold of the differential protection (parameter Threshold) and considers constant fault currents like magnetizing currents.

The characteristic branch b (parameter Intersection 1 Irest and Slope 1) considers current-proportional faults under normal operating conditions.

These faults can occur for the following reasons:

- Transformation errors in the current transformer and the input transformer of the device
- Adaptation deviations and tap changers in transformers with voltage control (but only if the tap changer position is not taken into account in the differential protection)

The characteristic curve branch c (parameter Intersection 2 Irest and Slope 2) secures the differential protection from overfunctions in case of high-current external faults and transformer saturation. In this area, transformer saturation can arise due to high short-circuit currents, and because of this a higher differential current results.

In order to avoid overfunction with external faults with current transformer saturation (also see Figure 6-7), a logic is implemented that uses the characteristic curve additional stabilization of external faults. If the operating point is located in the additional stabilization area and exceeds the operate curve from there, then the logic becomes active, and blocks the differential protection.

The additional stabilization range is derived from the Threshold add-on stabiliz. and Slope 1 parameters.

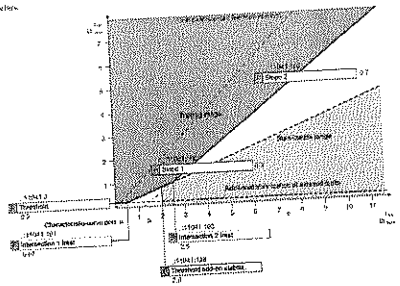

Figure 6-17 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0.7 does not reach the pickup characteristic, the pickup drops out.

Inrush-Current Detection

The inrush-current detection evaluates the calculated instantaneous values of the differential currents. The inrush current develops with sympathetic inrush – connection of a parallel transformer or recovery inrush – inrush current subsequent to returning voltage after a fault in the system in the differential current considerably higher than in the side currents. An assignment to the corresponding blocking phases is possible only in the differential current due to the vector-group connection.

The inrush-current detection is activated when the pickup characteristic is exceeded. It is deactivated when it is blocked by an external fault.

For inrush-current detection, 2 methods working in parallel are used:

- **Component of 2nd harmonic relative to the fundamental component in the differential current (I_{2nd}/I_{fund})**

  As also shown in Figure 6-8, the 2nd harmonic is clearly pronounced in the inrush current. If the component of the 2nd harmonic exceeds the set threshold value (parameter: 2nd harmonic content), a phase-segregated blocking occurs. The harmonics develop differently in the different phases. If exceeding of the 2nd harmonic is detected in a phase, it can be necessary to block all phases simultaneously. This blocking must be limited with regard to time and is controlled by the parameter Cross-block. time 2nd har.. The correct positioning of the filter windows is controlled by the internal pickup.

- **Curve form analysis (current wave shape analysis - CWA)**

  The occurrence of flat areas in the current curve is typical for a connection process (see Figure 6-18). If these flat areas occur in all 3 phases at the same point in time, this is a typical characteristic of the connection process. The method works as a supplement to the 2nd harmonic and covers cases that are not controlled through the 2nd harmonic. Based on the method of measurement, the blocking always affects all phases simultaneously. The method has internal, firmly set thresholds available.

  If the CWA method does not find any flat areas precisely one period after fault inception, an internal fault is detected, the 2nd harmonic and the CWA inrush method are blocked and the indication CWA int. fault detected is output. In this way, blocking or delayed tripping of the differential protection by the 2nd harmonic is prevented during the connection process with internal faults or current-transformer saturation.

If you want only one method to be active, the other method can be changed to inactive. The parameters Blocking with 2. harmonic and Blocking with CWA are used for this end.

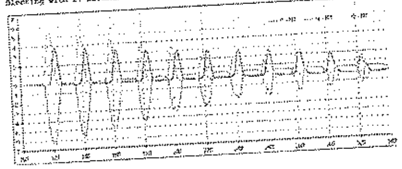

Figure 6-18 Inrush Current with Pronounced Flat Areas

Figure 6-19 shows the logical input and output signals.

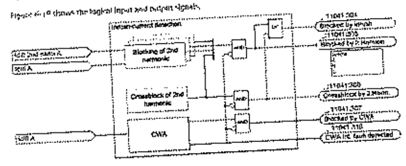

Figure 6-19 Logic Inrush-Current Detection

Blocking of Overexcitation

Stationary overexcitation is characterized by odd-numbered harmonics. Here the 3rd or 5th harmonic is suited to stabilization. Since with transformers, the 3rd harmonic is eliminated, for example, in the case of a delta winding, the 5th harmonic is used. The overexcitation blocking is activated when the pickup characteristic is exceeded. It is deactivated when it is blocked by an external fault.

Odd-numbered harmonics, which are not present with an internal short circuit, also play a role in converter transformers.

The shares of the 3rd and 5th harmonics in relation to the fundamental component are determined from the instantaneous values of the differential current via Fourier filters. If the threshold value (3rd harmonic content or 5th harmonic content) is exceeded, a phase-selective blocking occurs. It is also possible here to block all 3 phases simultaneously via the crossblock function (parameter: Crossblock. time 3rd har. or Crossblock. time 5th har.). Contrary to the 2nd harmonic, the overexcitation stabilization becomes inactive if the differential current (fundamental component value) exceeds a limiting value (parameter: Limit Idiff 3., 5. harmonic).

The Figure 6-20 shows the logical input and output signals.

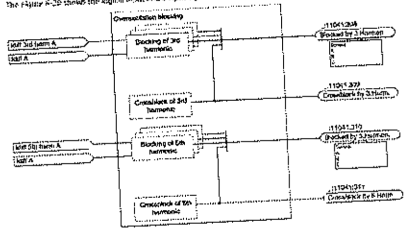

Figure 6-20 Behavior under Different Fault Conditions

Detection of External Short Circuits

To reliably detect external short circuits with transformer saturation, the measuring curve is evaluated in the first level with a detector. The detector has 2 essential tasks:

- **Blocking in the case of an unambiguous high current external short circuit**

  The differential current and the restraint current are monitored on a phase basis in the Differential level immediately after fault inception. To ensure the stability of the saturation detection for low saturation-free times of the primary current transformer, estimated values based on the difference quotients of the instantaneous values are used.

  If the estimated restraint current exceeds the Threshold add-on stabiliz. parameter and the expected value of the differential current of all phases are in the additional stabilization range (parameter Slope 1) (Figure 6-17) simultaneously, the detector is active and the indication Blocked by ext. fault phsx appears. The tripping of the Differential protection function is blocked.

  If an external short circuit arises and is cleared by the protection responsible for it, the additional stabilization drops out. If the dropout ratio (0.7) of the RMS value of the restraint current does not reach the Threshold add-on stabiliz. parameter (Figure 6-17), the additional stabilization drops out. The indication Blocked by ext. fault phsx is reset.

  If the differential current exceeds Slope 1 as a result of transformer saturation, that is, there is a pickup, the blocking is limited in time (parameter: Time of add-on stabiliz.).

  Starting with the indication Blocked by ext. fault phsx the other phases can be blocked with it via the Crossblk. time add-on st. parameter. If differential currents spread to the other phases through the vector-group correction or zero-sequence current elimination subsequent to transformer saturation, this blocking is necessary.

- **Removal of the blocking with a change in fault location from external to internal**

  An internal short circuit can arise as a consequence of an external short circuit. This fault-location change must be recognized and the blocking must be removed. The critical case is a short circuit with current transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation the instantaneous values do not reach an internal threshold in the saturation-free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with crossblock.

  The blocking of the tripping (including crossblock) is removed and the indication Blocked by ext. fault phsx is reset.

DC-Component Detection

In accordance with Figure 6-7 low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization area is not attained, however.

To avoid an overfunction, the following steps are taken:

- The restraint current I_{restr} is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) $I_{rest,inst}$ = [illegible] and is checked for exceeding of the internal threshold. The result is I_{DC}. This current is compared to the restraint current [illegible].
- The differential current I_{diff} must lie below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter Factor increasing char. with a default setting of 2.3. Here, only the threshold value and the gradient 1 are raised (see Figure 6-21). The indication Increase of char. (DC) is issued. If the product of parameters Factor increasing char. and Slope 1 exceeds 0.85, the maximum increase of the raised Slope 1 is limited to 0.85.
- As additional criterion, the pickup indication Pickup (internal fault is present) or the indication of the additional stabilization Blocked by ext. fault phsx (high current external fault) is interrogated. If 1 of the 2 conditions is present, the characteristic curve increase is stopped. A respective pickup no longer resets the characteristic curve increase. A pickup with DC component detection occurs only if the raised operate curve is exceeded.

If the DC component I_{DC} falls below the internal dropout threshold, the dropout delay is determined as follows:

It is assumed that the decay and remagnetization of the transformer last equally long. The magnetization is at the highest at the point in time at which the internal dropout threshold is attained. The time is measured from the start of the DC component detection until the internal dropout threshold is reached. Added to this time are 5 periods and from this, the dropout delay is derived. Following this, the characteristic curve increase is reset to the original value. Figure 6-22 shows the overall logic.

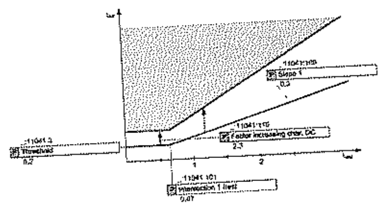

Figure 6-21 Increasing the Characteristic Curve after DC Detection

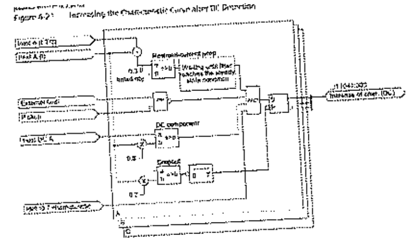

Figure 6-22 Logic DC Detection

Startup Detection

The pickup value increase is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetization and being supplied with current at different operating points of their hysteresis. These differential currents are low in fact, but with sensitive setting of the differential protection they can lead to overfunction.

As additional security against overfunction when switching in a previously protected object that carries no current, you can use the pickup value increase at startup. If the restraint current falls below a settable value in all phases through [illegible] startup detection the pickup value increase is activated. The pickup value

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Threshold and Slope 1 are raised by the set value in accordance with parameter Factor increasing char.. As a rule here, Slope 1 cannot exceed a value of 0.85.

If the parameter Thresh. startup detection is exceeded, startup occurs and a timing element (parameter Max. perm. Start. time) is activated. Once this time has elapsed, the characteristic curve that was increased in all phases is reset to its original value. Figure 6-23 shows the logic diagram of the startup detection and Figure 6-24 the increased characteristic curve.

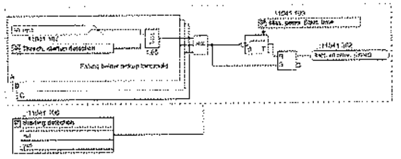

Figure 6-23 Logic Startup Detection

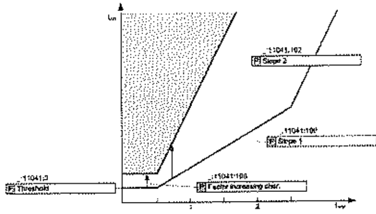

Figure 6-24 Characteristic Curve Increase at Startup

Trip Logic of the Differential Protection Function Idiff

Figure 6-25 shows the trip logic. If the characteristic curve is exceeded (see Figure 6-17) a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following influencing variables:

- Recognition of a connection process (2nd harmonic and CWA method)
- Identification of further harmonics (3rd and 5th harmonics (overexcitation detection))
- Detection of external short circuits that can simulate an internal short circuit through transformer saturation

Additionally, the Crossblock may function operate with blocking functions, depending on the settings.

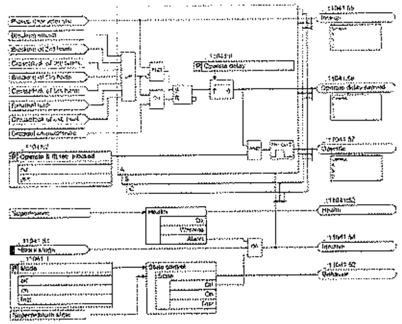

Figure 6-25 Trip Logic of Idiff

6.2.3.7 Differential Protection Function (Idiff Fast)

As a supplement to the differential protection function (Idiff), the Idiff fast function is available. The main task consists in switching off high-current internal short circuits in the shortest amount of time. The method controls current-transformer saturation and is stable in the event of external transverse faults (see Figure 6-26).

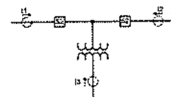

Figure 6-26 External Fault in a 1 1/2 Circuit-Breaker Application

Metrologically, 2 methods are combined:

- Instantaneous value method
- Filter-based method

Instantaneous Value Method

Through the instantaneous-value method, an immediate evaluation of the sampled values of the differential current and restraint current I_{rest} occurs. The absolute value adapted and vector group adapted currents are also the basis. The currents are defined positively to the node. The restraint current is the maximum current of all measuring points.

$$i_{diff,phase}(t) = \left|\sum_{m=1}^{N} i_{m,phase}(t)\right|$$

$$i_{restrain}(t) = \mathrm{MAX}_{m=1}^{N}\left|i_{m,phase}(t)\right|$$

with

i	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points

The evaluation of the restraint current is used to recognize saturated, high-current external short circuits (see Figure 6-26).

Figure 6-27 shows the operate curve. The parameter Threshold is set here such that it lies over the maximum fault current flowing. The gradient of the characteristic curve is fixed at 0.8.

In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current $di_{rest}(t)/dt$ is determined continuously and compared with an internal threshold.
- Condition 2: After that, a comparison determines whether the differential current is larger than the restraint current (characteristic curve gradient in Figure 6-27): $i_{diff}(t) > 0.8 \cdot i_{rest}(t)$.
- Condition 3: After that, a comparison determines whether the differential current exceeds the parameter Threshold.

When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the function is blocked for 300 ms.

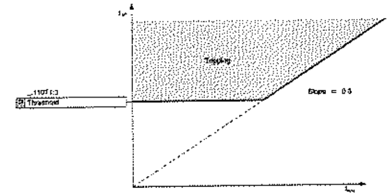

Figure 6-27 Characteristic Curve of Idiff Fast

The 2 figures below show the behavior during an internal and an external short circuit. It is typical for the internal short circuit (Figure 6-28) that the differential current rises more quickly than the restraint current. After a few sampled values, the trip signal is issued. In case of an external short circuit, a differential current arises only after transformer saturation occurs. You can always assume, however, that the current is transferred a few milliseconds after occurrence of the fault. In accordance with Figure 6-29, the restraint current is larger than the differential current after occurrence of the fault, but condition 2 is not met and the function is therefore blocked.

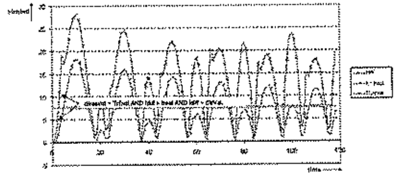

Figure 6-28 Curve Plot for Internal Short Circuit with Transformer Saturation (k = 0.8)

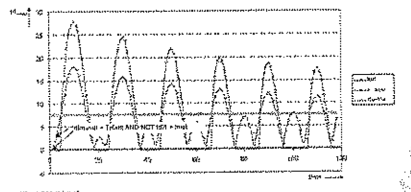

Figure 6-29 Curve Plot for External Short Circuit with Transformer Saturation (k = 0.8)

Fundamental Component

The fundamental-component method works with a temporal delay in parallel to the instantaneous-value method. Here, the same measured values are processed as with the Idiff method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) I_{rest} are entered in the operate curve Figure 6-27 and the trip decision is made.

Figure 6-30 shows the overall logic.

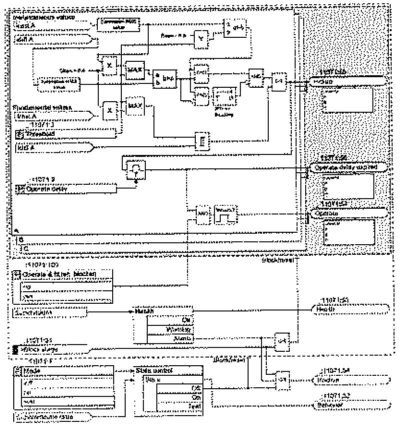

Figure 6-30 Logic of the Differential Protection Function Idiff Fast

6.2.3.8 Trip Logic of the Differential Protection

In accordance with Figure 6-9, a combined trip signal is formed from both subfunctions Idiff and Idiff fast. Figure 6-31 shows the appropriate logic.

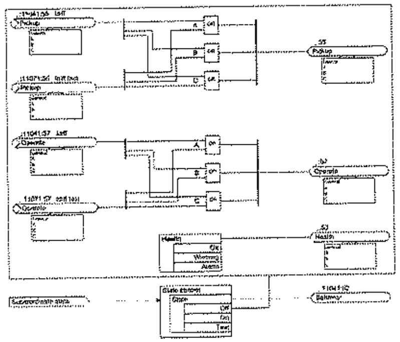

Figure 6-31 Overall Trip Logic

Functional Measured Values

Measured Value	Description
_:2311:300 A, B, C	Differential current
_:2311:302 A, B, C	Restraint current

6.2.3.9 Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Saving of the fault record depends on the setting (see 3.4.5 Function Description). Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with an external short circuit, along with the exceedance of the characteristic curve, a fault record is opened in case of blocking by an external short circuit or inrush characteristic curve increase through DC-component recognition. This has the advantage that you can evaluate the transformer transfer method of the current transformers [illegible] in case of a fault.

6.2.4 Application and Setting Notes

Selected applications for differential protection are described in the following. Setting instructions for the necessary setting parameters are given for these applications.

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Protection of a Two-Winding Transformer

As an example a transformer in the vector group YNd5 is selected, whose neutral side is solidly grounded. If different settings are produced by various versions (vector group, grounding), reference to them is made for the corresponding setting parameters. Figure 6-32 shows the basic structure with the typical setting ranges. The function is applicable in the devices 7UT82, 7UT85, 7UT86, and 7UT87.

> **NOTE**
>
> Also, observe the connection of the current transformer 8.10 Connection Examples for Current Transformers in the Appendix.

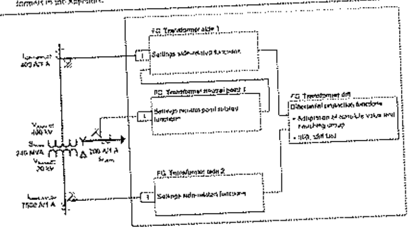

Figure 6-32 Connection

In the example, a 7UT85 is selected. 2 measuring inputs are interconnected on the 3-phase measuring points of side 1 and side 2. The measuring points must be interconnected with the corresponding function groups. Figure 6-33 shows the corresponding screenshot from DIGSI 5.

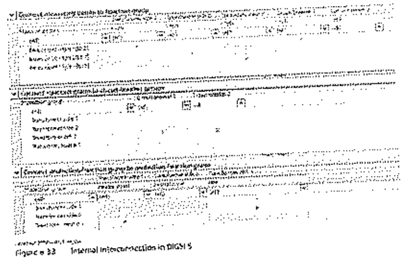

Figure 6-33 Internal Interconnection in DIGSI 5

Transformer Side Function Group

In the Transformer side function group, make the following settings:

> **NOTE**
>
> Ensure that the correct transformer data are set at the measuring points.

Parameter: Rated apparent power

- Default setting (_:91:103) Rated apparent power = 240 MVA

When using this parameter, the Rated apparent power is set for the appropriate side. The setting value for both sides is the same with a two-winding transformer.

Parameter: Rated voltage

- Default setting (_:91:102) Rated voltage = 400 kV

When using this parameter, the Rated voltage is set for the appropriate side. For side 1 it is 400 kV. Set 20 kV for side 2 in the example.

If a transformer with tap changers is used but the position of the tap changers is not to be recorded by the differential protection, then set a medium-sized voltage as Rated voltage. Use the following relationship for the calculation:

$$V_{set} = 2\frac{V_{max} \cdot V_{min}}{V_{max} + V_{min}}$$

V_{set}	Voltage to be set
V_{max}	Voltage at upper tap position
V_{min}	Voltage at lower tap position

The calculated rated current of the side is displayed as additional information. In the example, this is a value of 346 A (240 MVA/(√3 · 400 kV) = 346.4 A).

Parameter: Neutral point

- Default setting (_:91:149) Neutral point = grounded

This parameter is important for zero-sequence current treatment. In the example, the transformer is solidly grounded on side 1. For this reason, set grounded. For side 2 (delta side) set isolated. If a neutral-point grounding is located within the protection range of the transformer differential protection on the delta side, set grounded. If a star winding is not grounded, then set isolated.

> **NOTE**
>
> If a star winding is implemented to an insulated with regard to the neutral-point treatment and a surge arrester is connected, then to avoid overfunction of the differential protection, the setting grounded is recommended. If the surge arrester picks up, then it grounds the neutral point.

Parameter: Winding configuration

- Default setting (_:91:154) Winding configuration = Y (Wye)

You set the interconnection of the windings with this parameter. Side 1 is interconnected in the star. For this reason, set Y (Wye). For side 2, which is interconnected in the delta, you must set D (Delta). If the windings are interconnected in zigzag, set Z (Zigzag).

Parameter: Vector group numeral

- Default setting (_:91:160) Vector group numeral = 0

The parameter is used to account for phase angle rotation, which is expressed by a numeral.

Phase angle rotation	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Vector group numeral	0	1	2	3	4	5	6	7	8	9	10	11

In the example a transformer YNd5 is used. For this transformer, side 1 gets the Vector group numeral 0 and side 2 the Vector group numeral 5.

In the function group, the following information is displayed additionally in the setting sheet:

- Side number
- Identification of the measuring points used
- Adaptation factor for the 3-phase measuring point (with reference to the side)
- Adaptation factor for the measuring point at the neutral point (with reference to the side)

You can set each vector group numeral from 0 to 11 to the extent possible. Even, for example, only even numbers are possible for the vector groups Yy, Dd, and Dz and only odd numbers are possible for Yd, Yz and Dy.

Parameter: Tap changer

- Default setting (_:91:44) Tap changer = No function block has been selected

When using this parameter, the transformer side is allocated to a tap changer. If a tap changer is assigned, other parameters also become visible. You can use a separate tap changer or the tap changer in the voltage controller.

Figure 6-34 Parameters in DIGSI 5

Parameter: Basic position

- Default setting (_:91:138) Basic position = 8

With the parameter Basic position you specify the stage at which the voltage matches the rated voltage of the transformer side.

Parameter: Volt. diff. adjacent taps

- Default setting (_:91:133) Volt. diff. adjacent taps = 0.000

With the Volt. diff. adjacent taps parameter, you set the voltage difference of a stage under idle conditions.

Transformer DIFF function group

Make the following settings in the Transformer DIFF function group for the test function:

Tap Changer

In the General setting sheet in DIGSI 5, you specify whether the adaptation of the differential protection to the current tap changer position is to be used. Make the setting and allocation in the transformer side.

Parameter: Use tap changer

- Default setting (_:2311:107) Use. tap changer = Yes

With setting Yes you adapt the differential protection function to the current tap changer position.

Zero-Sequence Current Treatment

You set how the ground current is handled on the General setting sheet in DIGSI 5. (In Transformer Side 1 the neutral point of the transformer is set as grounded. In this way, the protection function knows that the zero-sequence current is to be accounted for. With the following parameter you can set the treatment of the zero-sequence current.

Parameter: Meas. gnd. current side 1

- Default setting (_:2311:100) Meas. gnd. current side 1 = no

With the setting yes a zero-sequence current correction is performed. The setting no causes the elimination of the zero-sequence current. With the zero-sequence current correction, a higher sensitivity is attained in the case of 1-pole ground faults. If the neutral point current transformer should be taken into consideration in the differential protection, set yes.

> **NOTE**
>
> For this application design the neutral point current transformer appropriately strong (almost saturation-free over approx. 30 ms)
>
> More information on this in chapter 6.2.3.1 Basic Principle of Differential Protection, section Neutral point current handling

Parameter: Threshold (Setting the Characteristic-Curve Parameters)

- Default setting (_:11041:3) Threshold = 0.2 I/Irated,obj

You set the pickup threshold for the differential current with this parameter. This is the total current flowing into the protection range during a short circuit, regardless of how it is distributed on the sides of the protected object. The Threshold is referenced to the rated current of the protected object. With transformers, a sensitive setting can be selected since a relatively small magnetizing current arises as a constant fault current. The default setting of 0.2 I/Irated,obj is a practical value between sensitivity and possible disturbing influence.

If the transformer sets are of similar construction in the case of reactors, generators and motors (identical in transmission behavior), a more sensitive setting is possible.

In the event of a very pronounced deviation of the current-transformer rated currents from the rated current of the protected object or with several measuring points, expect greater measuring tolerances. If loads with large time constants (external transformers, motors) are connected, transmission problems (for example, through remanence) can arise with currents in the rated current range with a closed iron core transformer (cores). In this case, Siemens recommends an increased setting value of 0.3 Irated,obj.

If the position of the tap changer cannot or should not be taken into account in the differential protection, set the pickup value slightly higher than the default setting. Use the following relationship for orientation:

Threshold value$_{new}$ = Threshold value + k_{TC} · Irated,obj

$$k_{TC} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{(100\,\% + St_{max}) - (100\,\% + St_{min})}{(100\,\% + St_{max}) + (100\,\% + St_{min})}$$

k_{TC}	Correction value to account for the tap changer

Example: Tap changer St_{max} = +7.5%, St_{min} = −15%

$$k_{TC} = \frac{(100\,\% + 7.5\,\%) - (100\,\% - 15\,\%)}{(100\,\% + 7.5\,\%) + (100\,\% - 15\,\%)} = 0.1169$$

Threshold value$_{new}$ = 0.20 Irated,obj + 0.1169 Irated,obj ≈ 0.32 I/Irated,obj

Parameter: Slope 1

- Default setting (_:11041:100) Slope 1 = 0.3

> **NOTE**
>
> The stabilization method has been changed from that in SIPROTEC 4 (7UT6x, 7UM62). For this reason, select a higher gradient (also see 6.2.3.1 Basic Principle of Differential Protection).

If the position of the tap changer cannot or should not be taken into account in the differential protection, check the increase.

Slope 1 New = Slope 1 + 1.2 · k_{TC}

For example, Slope 1 = 0.3 + 1.2 · 0.1169 = 0.44

However, you should set a gradient of at least 0.3. Figure 6-35 illustrates the situation for you.

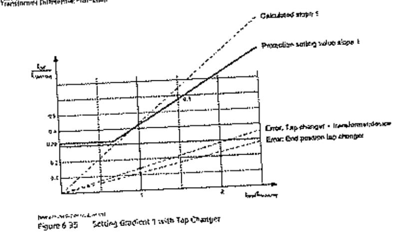

Figure 6-35 Setting Gradient 1 with Tap Changer

Parameter: Intersection 1 Irest

- Default setting (_:11041:101) Intersection 1 Irest = 0.67 I/Irated,obj

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission errors of the current transformer even with small currents, half of the rated current is an appropriate setting value.

If the position of the tap changer cannot or should not be taken into account in the differential protection, use the following formula to calculate the value for Intersection 1 Irest:

$$\text{Intersection 1 Irest}_{new} = \frac{\text{Threshold value}_{new}}{\text{Slope 1}_{new}}$$

$$\text{Intersection 1 Irest}_{new} = \frac{0.32\ \text{Irated,obj}}{0.44} = 0.73\ \text{Irated,obj}$$

For the example above with tap changer, the default setting of Intersection 1 Irest = 0.67 I/Irated,obj is feasible. With 0.67 Irated,obj < 0.73 Irated,obj an increased stabilization is achieved.

Parameter: Intersection 2 Irest

- Default setting (_:11041:103) Intersection 2 Irest = 2.5 I/Irated,obj

> **NOTE**
>
> If larger current flows are to expect transmission problems for the current transformer, set the Slope 2 to a higher value.

When using the Intersection 2 Irest parameter, you determine at which restraint current the Slope 2 will start. The default setting 2.5 I/Irated,obj is a practical value.

Parameter: Slope 2

- Default setting (_:11041:102) Slope 2 = 0.7

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With the Slope 2 parameter, an overfunction of the differential protection is avoided with high-current external faults as a consequence of current transformer transmission errors (for example, due to saturation). A value greater than or equal to double the value of Slope 1 is practical. As the default setting, 0.7 was selected.

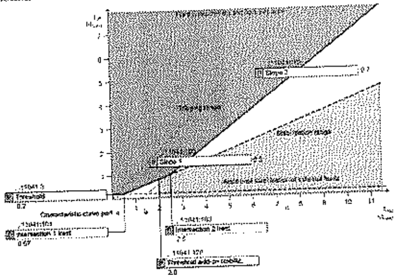

Figure 6-36 Characteristic Curve with the Default Settings

Parameter: Starting detection

- Default setting (_:11041:106) Starting detection = no

If motors are operated by a transformer to be protected, Siemens recommends the activation of the startup detection. The startup detection prevents an overfunction caused by the startup currents of the motors. Siemens recommends this also for the protection of power compensating reactors. In this case, set the default setting Starting detection = yes.

Parameter: Thresh. startup detection

- Default setting (_:11041:107) Thresh. startup detection = 0.1 I/Irated,obj

If the restraint current falls below this threshold value, the subsequently set characteristic curve increase becomes effective with activated function. For this application, Siemens recommends a default setting of 0.1 I/Irated,obj.

Parameter: Factor increasing char.

- Default setting (_:11041:108) Factor increasing char. = 2.0

Change the default setting value in the case of application. A setting to the value 2.0 has proven itself to be sufficient for many applications. For this reason, the recommended setting value is Factor increasing char. = 2.0.

Parameter: Max. perm. Start. time

- Default setting (_:11041:109) Max. perm. Start. time = 5.0 s

The setting value must lie above the maximum permissible start time of the connected motors. Find the start time in the motor data sheets (for example, Locked Rotor time). To guarantee tripping through the motor protection (starting-time supervision and avoid overfunctions, select a somewhat longer time (factor 1.2).

Parameter: Factor increasing char. DC (DC-component detection)

- Default setting (_:11041:110) Factor increasing char. DC = 2.3

DC-component detection is always active. As a result of the DC components, transmission problems can arise (for example, phase-angle rotations) in current transformers with small currents flowing. For this reason, the Threshold and the Slope 1 are increased by the set factor. The default setting of 2.3 has proven itself with numerous applications.

Parameter: Blocking with 2. harmonic (Inrush-Current Detection)

- Default setting (_:11041:115) Blocking with 2. harmonic = yes

Always activate inrush-current detection with transformer applications.

Parameter: 2nd harmonic content

- Default setting (_:11041:116) 2nd harmonic content = 15 %

For many practical applications, the default setting value of 15 % has proven useful. In exceptional cases, the setting value can be decreased with a small proportion of 2nd harmonic. Avoid a setting under 10 %, however. With an internal fault and current transformer saturation, a proportion of 2nd harmonic also arises. Too sensitive of a setting leads to a blocking of the protection function.

Parameter: Crossblock. time 2nd har.

- Default setting (_:11041:117) Crossblock. time 2nd har. = 0 s

Since the inrush currents develop differently in the 3 phases, the pickup value, for example, is not attained in a phase, but the differential current exceeds the characteristic curve. Corrective action creates a mutual blocking. If a time unequal to 0 s is set, the crossblock function works. If an overfunction arises, the setting cannot be made until commissioning takes place. Do not set the duration for an excessive amount of time. Practical values showed a setting between 3 and 5 periods.

Parameter: Blocking with CWA

- Default setting (_:11041:118) Blocking with CWA = yes

In accordance with the application sheet, an additional, supplementary method is used for the inrush current detection. Siemens recommends using the default setting. If you wish to perform the inrush current detection only when monitoring the 2nd harmonic, you can switch off the CWA method (Blocking with CWA = no).

Parameter: Blocking with 3rd harm. (Overexcitation Blocking)

- Default setting (_:11041:121) Blocking with 3rd harm. = no

Blocking with the 3rd harmonic is intended for special applications, for example, when supplying power to blast furnaces. Even with standard transformers, the 3rd harmonic can arise in a case of overexcitation, but this is eliminated through the delta winding. For this reason, using the 5th harmonic is preferred.

Parameter: 3rd harmonics content

- Default setting (_:11041:122) 3rd harmonics content = 30 %

For many practical applications, the default setting value of 30 % has proven useful. Also see explanations for setting the 5th harmonic.

Parameter: Crossblock. time 3rd har.

- Default setting (_:11041:123) Crossblock. time 3rd har. = 0 s

See explanation of inrush-current detection.

Parameter: Blocking with 5th harm.

- Default setting (_:11041:124) Blocking with 5th harm. = no

If you expect higher overvoltages that can bring about a failure of the differential protection, change the default (also see explanations below) and activate the functionality Blocking with 5th harm. = yes.

Parameter: 5th harmonics content

- Default setting (_:11041:125) 5th harmonics content = 30 %

For many practical applications, the default setting value of 30 % has proven useful. It can be derived from the Figure 6-37 in the graphic shown. The voltage is represented on the x-axis, and the percentage of the individual measurable variables on the y-axis. On the curve I_{diff}/I_{rated} you can see that the pickup value of the differential protection can be exceeded in case of overvoltage. If you assume 140 % (V_{rated}) as the maximum overvoltage, you can read from the curve I_{5f}/I_{1f} that the proportion of the 5th harmonic still amounts to approx. 35 %. A setting value of 30 % is therefore sufficient.

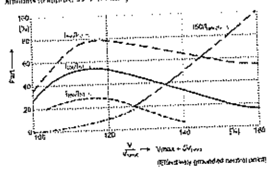

Figure 6-37 Part of the Harmonic in Case of Overexcitation

Parameter: Crossblock. time 5th har.

- Default setting (_:11041:126) Crossblock. time 5th har. = 0 s

You can leave the default as is. If problems arise during system operation, you can take corrective measures by setting an appropriate time. You can derive the necessary time from the fault record by evaluating the proportion of the harmonic.

Parameter: Limit Idiff 3., 5. harmonic

- Default setting (_:11041:127) Limit Idiff 3., 5. harmonic = 1.5 I/Irated,obj

If large differential currents arise, you can assume an internal fault. In order to avoid a subfunction of the differential protection, overexcitation blocking is prohibited from the threshold value on. Because fault currents produce predominantly odd-numbered harmonics in case of an internal fault. In accordance with Figure 6-37, a possible differential current is caused that lies below the rated current due to overexcitation. On the other hand, distinct fault currents arise only with currents far above the rated current. Therefore, 1.5 I/Irated,obj is a practical setting value.

Detection of External Faults

In Figure 6-36, the range Additional Stabilization with External Fault is represented. The range is described by the parameters Threshold add-on stabiliz. and Slope 1. With an external short circuit, the differential currents can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: Threshold add-on stabiliz.

- Default setting (_:11041:120) Threshold add-on stabiliz. = 2.0

The Threshold add-on stabiliz. parameter allows you to set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of 2 is practical. The additional stabilization range is limited by the parameters Threshold add-on stabiliz. and Slope 1.

Parameter: Time of add-on stabiliz.

- Default setting (_:11041:129) Time of add-on stabiliz. = 0.3 s

As orientation for the setting value, you can use the operate time of the external feeder protection. Additionally, take into account the opening time of the circuit breaker. Thus, the following calculation rule results:

$T_{min} \geq T_{protection} + T_{circuit\ breaker}$

The default value is a practical value. You must adapt the value appropriately to use. The value 0 deactivates the recognition of external errors.

Parameter: Cross-blk. time add-on st.

- Default setting (_:11041:130) Cross-blk. time add-on st. = 0.3 s

As a consequence of the vector-group correction and zero-sequence current elimination, the differential currents can spread to the other phases in case of transformer saturation. For this reason, Siemens recommends the activation of the crossblock function by means of a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Protection Stage Idiff Fast

The task of this protection stage is the fast capture of high-current internal faults (see also 6.2.1 Basic Principle of Differential Protection). For this reason, the protection stage must always be activated.

Parameter: Threshold

- Default setting (_:11072:3) Threshold = 7.5 I/Irated,obj

The Threshold must exceed the expected inrush current. The inrush current depends on the construction, the core material and the impedances of the transformer. There are typical power-dependent values. Use the graphic below for estimating purposes (Figure 6-38).

In the case of transformers with a low power rating (<10 MVA) the inrush current can lie above the default setting value of 7.5 I/Irated,obj.

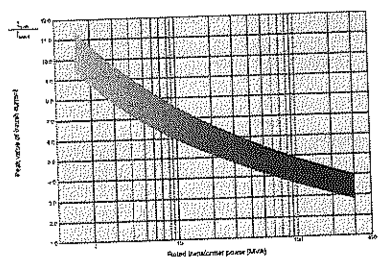

Figure 6-38 Transformer Inrush Currents, Typical Data

Example:

At a power of 100 MVA, a value of approx. 4.5 Irated,Obj is derived from Figure 6-38. For this application, reduce the default setting from 7.5 Irated,Obj to the determined value.

Protection of a Three-Winding Transformer with Several Measuring Points

In this complex example, the main focus is on the configuration. A three-winding transformer YNd1d1, which is connected on the upper voltage side to a breaker-and-a-half layout, is protected. A generator feeds in power on this delta side, while a generator also supplies its own power. On the upper voltage side, the transformer is solidly grounded. As can be seen in Figure 6-39, five 3-phase measuring points and one 1-phase measuring point is required. A 1-phase overcurrent protection is located in the 1-phase measuring point at ground point current backup protection. So that the restricted ground-fault protection found there can process the neutral point current, interconnection with the Transformer side 1 is required. The individual measuring points are described by ID1 to ID6. Further, 3 function groups Transformer side, a function group Transformer neutral point and the function group Transformer are necessary. The functionality is available in the devices 7UT86 and 7UT87.

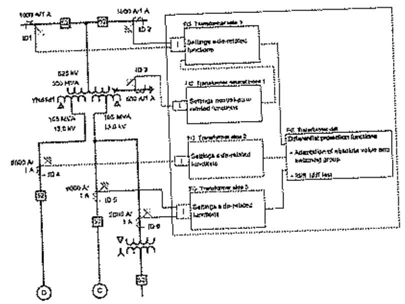

Figure 6-39 Connection of a Three-Winding Transformer with Several Measuring Points

Figure 6-40 shows you the measuring point assignment to the function groups and the interconnection of the function groups among one another from DIGSI 5. Since a total of 5 circuit breakers are operated, 5 function groups Circuit Breaker are present.

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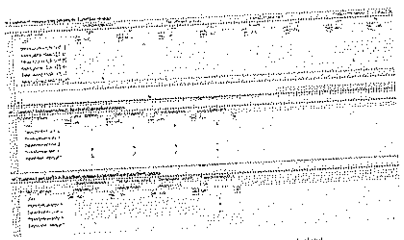


Figure 6-40 Interconnection of the Measuring Points and Function Groups (continued)

Make the settings in the Transformer side function group, using the approach described for the two-winding transformer. Ensure that the transformer data with the measuring points have been set. The following screenshot shows the settings for the Transformer side 1 function group (upper-voltage side).

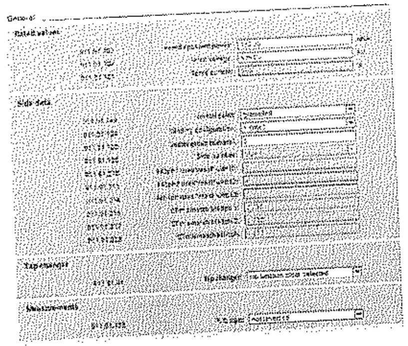


Figure 6-41 Setting the Transformer Side 1 Function Group

Besides the standard data of the transformer side, additional information is stored. These are colored gray. The following values are displayed.

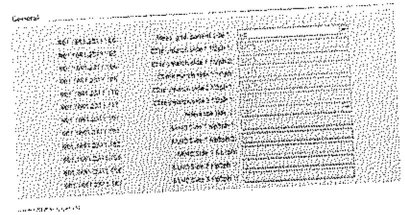
- Side number of the transformer side
- IDs of the assigned measuring points
- Side-related adaptation factors for the current correction

NOTE

Ensure that the current correction factors refer to the side.

The rated current of the side amounts to 363 A and phase current transformers of 1 000 A/1 A are present. The adaptation factor results in 1 000 A/363 A = 2.76. For the neutral point transformer 500 A/363 A = 1.38 is the result.

Analog to the two-winding transformer, the identical setting parameters for the transformer function group may be used. Figure 6-42 shows the respective setting sheet for the IDiff stage.



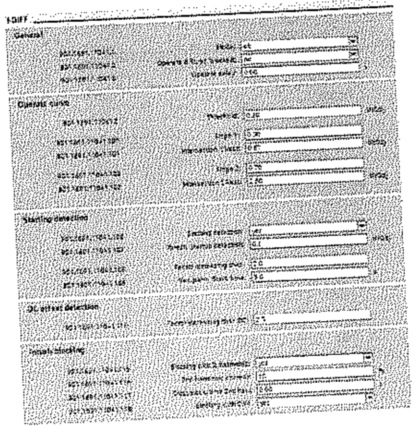


Figure 6-42 Setting in the Transformer Function Group (1)

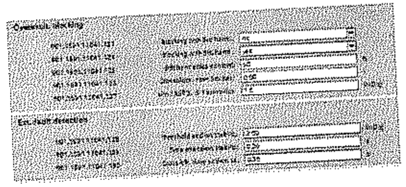


Figure 6-43 Setting in the Transformer Function Group (2)

You set how the ground current is handled on the General setting sheet. The neutral point of the transformer is grounded is set on the transformer side (Figure 6-41). In this way, the protection function knows that the zero-sequence current is to be accounted for. With the following parameter you can set the treatment of the zero-sequence current.

Parameter: Meas. gnd. current side 1

- Default setting (_:17311:100) Meas. gnd. current side 1 = no

With the setting yes a zero-sequence current correction is performed. The setting no causes the elimination of the zero-sequence current. With the zero-sequence current correction, a higher sensitivity is attained in the case of 1-pole ground faults. If the neutral point current transformer and the differential protection are connected, you must set yes. Ensure beforehand that you have set the transformer data with the measuring points.

Further explanations for zero-sequence current handling can be found in the 6.2.3.2 Basic Principle of Differential Protection.

Additionally, the correction factors that the differential protection uses for current adaptation are shown under General. The currents are based on the transformed rated current of the reference side.

NOTE

The reference side is the side with the highest rated apparent power. If this should be several sides, the largest side rated current is selected from these.

Since side 1 is the side with the greatest power, the adaptation factors are identical to those in the function group Transformer Side. For side 2 the following adaptation results: I_{rel} = (500 MVA/(√3 · 38 kV · √3)) = 13 806 A, 8000 A/13 806 A = 0.58. Since 2 measuring points with different primary rated currents are connected on side 3, 2 different adaptation factors result. For the 2 000 A transformer, that is 2 000 A/13 806 A = 0.14.

Protection of an Auto transformer with Stabilizing Winding

In addition to the configuration, this example focuses on present on relevant implementation. A stabilizing winding that is connected on the upper-voltage side to a 1 1/2 circuit breaker application is used to protect the transformer bank. Figure 3 shows the system integration and the internal interconnection of the function groups. Altogether, four 3-phase voltage measuring points are processed. The auto transformer also has a 3-phase current transformer (ID4) at the neutral point. Differential protection which treats the auto transformer as a pure node can be realized additionally. You thereby attain a higher sensitivity in faults near the neutral

points on the basis of how the transformer bank is set up, these are 1-pole ground faults. Settings instructions are given below.

NOTE

This supplemental protection function does not record the stabilizing windings!

In contrast to this, the conventional differential protection function also takes into consideration the stabilizing winding. The measuring points ID1, ID2, ID3 and ID5 are processed. The protection function is identical to the function of the standard transformer. You can read settings instructions below. The function is operational in the devices 7UT86 and 7UT87.

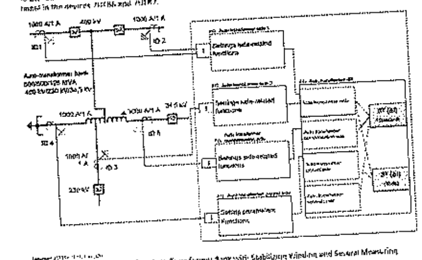


Figure 6-44 Connection of an Auto Transformer Bank with Stabilizing Winding and Several Measuring Points

From Figure 6-44 it can be seen that 4 function groups are required side-specifically. The connection of the measuring points to this and the side-specific settings occur. The differential protection functions are processed in the Auto transformer diff function group. The 2 differential protection functions run in parallel in the application. Figure 6-44 also shows the interconnection of the function groups to the different interfaces of the function group Auto transformer diff. The auto transformer neutral point interface is used for applications where a 1-phase current transformer is present at the neutral point. In this application, connect the current transformer with ♦ Auto transformer neutral point function group.

6.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:186	General:Protection Mode		• Transformer • Current node	Transformer
_:2311:103	General:Meas. gnd. current side 1		• no • yes	no

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Addr.	Parameter	C	Setting Options	Default Setting
_:2311:101	General:Meas. gnd. current side 2		• no • yes	no
_:2311:102	General:Meas. gnd. current side 3		• no • yes	no
_:2311:103	General:Meas. gnd. current side 4		• no • yes	no
_:2311:104	General:Meas. gnd. current side 5		• no • yes	no
_:2311:181	General:Meas. gnd. curr. autosides		• no • with CT 1ph • with CT 3ph	no
_:2311:182	General:Meas. gnd. curr. comp.side		• no • yes	no
_:2311:191	General:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:2311:151	General:MU-ID Side 1 Mp3ph 1		0 to 100	0
_:2311:152	General:MU-ID Side 1 Mp3ph 2		0 to 100	0
_:2311:153	General:MU-ID Side 1 Mp3ph 3		0 to 100	0
_:2311:154	General:MU-ID Side 1 Mp3ph 4		0 to 100	0
_:2311:155	General:MU-ID Side 1 Mp1ph		0 to 100	0
_:2311:156	General:MU-ID Side 2 Mp3ph 1		0 to 100	0
_:2311:157	General:MU-ID Side 2 Mp3ph 2		0 to 100	0
_:2311:158	General:MU-ID Side 2 Mp3ph 3		0 to 100	0
_:2311:159	General:MU-ID Side 2 Mp3ph 4		0 to 100	0
_:2311:160	General:MU-ID Side 2 Mp1ph		0 to 100	0
_:2311:161	General:MU-ID Side 3 Mp3ph 1		0 to 100	0
_:2311:162	General:MU-ID Side 3 Mp3ph 2		0 to 100	0
_:2311:163	General:MU-ID Side 3 Mp3ph 3		0 to 100	0
_:2311:164	General:MU-ID Side 3 Mp3ph 4		0 to 100	0
_:2311:165	General:MU-ID Side 3 Mp1ph		0 to 100	0
_:2311:166	General:MU-ID Side 4 Mp3ph 1		0 to 100	0

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:167	General:MU-ID Side 4 Mp3ph 2		0 to 100	0
_:2311:168	General:MU-ID Side 4 Mp3ph 3		0 to 100	0
_:2311:169	General:MU-ID Side 4 Mp3ph 4		0 to 100	0
_:2311:170	General:MU-ID Side 4 Mp1ph		0 to 100	0
_:2311:171	General:MU-ID Side 5 Mp3ph 1		0 to 100	0
_:2311:172	General:MU-ID Side 5 Mp3ph 2		0 to 100	0
_:2311:173	General:MU-ID Side 5 Mp3ph 3		0 to 100	0
_:2311:174	General:MU-ID Side 5 Mp3ph 4		0 to 100	0
_:2311:175	General:MU-ID Side 5 Mp1ph		0 to 100	0
_:2311:185	General:MU-ID Mp1ph		0 to 100	0
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.30 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	no
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	1.0
_:11041:109	I-DIFF:Max. perm. Start. time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Inrush blocking				
_:11041:115	I-DIFF:Blocking with 2. harmonic		• no • yes	yes
_:11041:116	I-DIFF:2nd harmonic content		10 % to 45 %	15 %

Addr.	Parameter	C	Setting Options	Default Setting
_:11041:117	I-DIFF:Crossblk. time 2nd har.		0.00 s to 200.00 s	0.00 s
_:11041:118	I-DIFF:Blocking with CWA		• no • yes	yes
Overexcit. blocking				
_:11041:121	I-DIFF:Blocking with 3rd harm.		• no • yes	no
_:11041:122	I-DIFF:3rd harmonic content		10 % to 80 %	30 %
_:11041:123	I-DIFF:Crossblock. time 3rd har.		0.00 s to 200.00 s	0.00 s
_:11041:124	I-DIFF:Blocking with 5th harm.		• no • yes	no
_:11041:125	I-DIFF:5th harmonic content		10 % to 80 %	30 %
_:11041:126	I-DIFF:Crossblock. time 5th har.		0.00 s to 200.00 s	0.00 s
_:11041:127	I-DIFF:Limit Idiff 3., 5. harmonics		0.5 I/IrObj to 20.0 I/IrObj	1.5 I/IrObj
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s	0.30 s
_:11041:130	I-DIFF:Cross-bl. time add-on st.		0.00 s to 2.00 s	0.30 s
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no

6.2.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I restr.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I restr. operate phA	MV	O
_:2311:315	General:I restr. operate phB	MV	O
_:2311:316	General:I restr. operate phC	MV	O
_:2311:317	General:Adapt. adjustm. fact.	SPS	O

No.	Information	Data Class (Type)	Type
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Incr. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:304	I-DIFF:Blocked by inrush	ACT	O
_:11041:305	I-DIFF:Blocked by 2.Harmon.	SPS	O
_:11041:306	I-DIFF:Crossblock by 2.Harm.	SPS	O
_:11041:307	I-DIFF:Blocked by CWA	ACT	O
_:11041:308	I-DIFF:Blocked by 3.Harmon.	SPS	O
_:11041:309	I-DIFF:Crossblock by 3.Harm.	ACT	O
_:11041:310	I-DIFF:Blocked by 5.Harmon.	SPS	O
_:11041:311	I-DIFF:Crossblock by 5.Harm.	ACT	O
_:11041:312	I-DIFF:Blocked by ext. fault	SPS	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O
_:11041:314	I-DIFF:CWA int. fault detected	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:54	I-DIFF fast:Inactive	SPS	O
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:58	I-DIFF fast:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

6.3 Differential Protection for Phase-Angle Regulating Transformer

6.3.1 Overview of Functions

The **Differential protection for phase-angle regulating transformers** (PST) function supplements the existing **Transformer differential protection** function (ANSI 87T). You can find the structure of the function in chapter 6.2.2 Structure of the Function.

Phase-angle regulating transformers are used to control the reactive-power flow and active-power flow in high-voltage power systems. The objective is to achieve voltage stability, a uniform load dispatching in parallel transmission lines, and to prevent unbalanced current in the meshes of the transmission systems.

The main function of the phase-angle regulating transformer is to alter the effective phase displacement between the input and output voltage of a transmission line. This function controls the amount of current that can be transmitted by a single line.

In order to apply an introduced voltage boost to influence the active-power flow, phase-angle regulating transformers are integrated into the electrical power system in series. This situation arises, for example, if an increase in the transmission capacity is required due to the installation of an additional line. By using selective control of the angle between the current and the voltage in a line, both lines can be used up to their projected load limit.

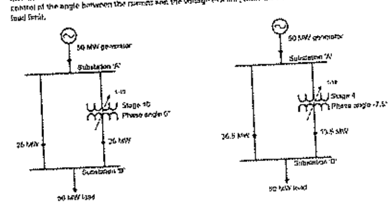

Figure 6-45 Power Distribution between 2 Lines when Using Different Phase-Angle Values

The control of the power flow or the energy flow direction at the tie points of 2 electrical power systems is another typical application.

In order to parameterize the Transformer differential protection for the phase-angle regulating transformer application, add a corresponding function block from the DIGSI 5 library to the Transf.DIFF function group.

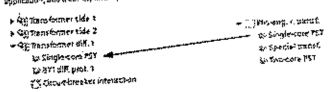

Figure 6-46 Instances of the Phase-Angle Regulating Transformer

There are 3 function blocks available for the adaptation to the various types of phase-angle regulating transformers:

Single-Core PST — Phase-angle regulating transformers of the single-core transformer type. These transformers contain all necessary windings on a 3-phase transformer core. When the angle is adjusted, the absolute value of the voltage does not change linearly. In order to compensate for the change in the absolute value of the voltage, an additional voltage controller (transformer with in-phase regulation) is usually required.

Special transf. — Special transformers. Special transformers are transformers with a fixed interconnection of the windings. This will result in a vector-group number that is not an integer value (for example, SG 0.25 = 7.5°). They can be used, for instance, as converter transformers. When the rectified currents from several windings are joined with shifted phase displacements, the result is reduced ripple of the direct current.

Two-Core PST — Phase-angle regulating transformers of the two-core transformer type. These transformers connect the phase-shifted voltage via an adjustable shunt transformer. Therefore, the tap changer does not carry the load current and is suitable for higher power levels. The absolute value of the voltage ratio does not change with the angle.

The transformer differential protection automatically considers the resulting change in the absolute value and change in angle. Therefore, the changes do not need to be taken into consideration in the pickup characteristic settings for the differential protection.

The switch makes it possible to change between negative and positive no-load phase displacement even under full load. In this case, blocking of the I-DIFF stage of the differential protection is adjustable.

6.3.2 Phase-Angle Regulating Transformers of the Type Single-Core PST

The phase-angle regulating transformer of the type single-core PST consists of a 3-phase series winding and a 3-phase excitation winding. The excitation winding uses a delta connection and induces the voltage ΔV in the series winding. The excitation winding is installed on the same transformer core.

You can use one or several tap changers to change the phase displacement and the output voltage of the transformer.

The differential protection of this transformer requires information regarding the position of the tap changer, information about the no-load voltage, and the angle of the respective stage. The following figure shows the corresponding connection of an asymmetrical single-core transformer scheme, Single-core PST.

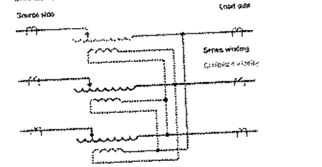

Figure 6-47 Asymmetrical Single-Core Transformer Scheme, Single-Core PST

Configure the differential protection for the phase-angle regulating transformer by adding the Single-core PST function block to the Transformer differential protection function.

- Transformer side 1
- Transformer side 2
- Transformer diff. 1
  - Single-core PST
  - 87T diff. prot. 1
  - Circuit-breaker interaction
- Circuit breaker 1
- Circuit breaker 2
- Tap changer 1
- Tap changer 2

Figure 6-49 Instance of the Single-Core PST Function Block

After instantiation of the Single-core PST function block, additional parameters are displayed in the Transformer side function group and in the Transformer differential protection function group.

The tap changers for the phase-angle regulation and the in-phase regulation are assigned to the transformer side. The phase-angle regulating transformer tap changer detects the voltage and the angle for each tap-changer position.

If using asymmetrical phase-angle regulating transformers, changing the phase angle also affects the voltage. Therefore, a second tap changer may be required in order to compensate for the changed absolute value of the voltage. This additional tap changer collects the information required to correct the voltage of the transformer with in-phase regulation.

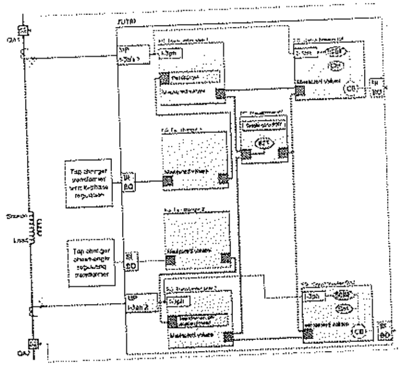

Figure 6-49 Logic of the Single-Core PST Function Block

The Figure 6-50 and the Figure 6-51 show the settings for the tap changer adaptation for the transformer sides 1 and 2. Additional settings of the tap changer are described in chapter 2.8 Transformer Tap Changers.

Tap changer		
911.91.44	Tap changer:	Tap changer 1.Tap changer
911.91.138	Basic position:	8
911.91.139	Volt. diff. adjacent taps:	10.000 kV

Figure 6-50 Setting of the Tap Changer for Transformer Side 1

Tap changer phase		
911.91.45	Tap changer:	Tap changer 2.Tap changer

Table of angles			
911.91.166	Table of angles:	Pos[]	Angle[°]
		1	0.000
		2	0.000
		3	0.000
		4	0.000
		5	0.000

Table of voltages			
911.91.166	Table of voltages:	Pos[]	Vtg [kV]
		1	0.000
		2	0.000
		3	0.000
		4	0.000
		5	0.000

Figure 6-51 Setting of the Tap Changer for Transformer Side 2

You can use the set table values to adjust the differential protection to the control of the transformer. This prevents additional differential currents that are caused by different tap-changer positions.

Set the software filtering time for the binary inputs of the tap changer. This software filtering time avoids the fact that the transient states in the binary image of the tap-changer position lead to an incorrect adaptation of the differential protection during the transition from one stage to the next. When you set the software filtering time, you must take into consideration the runtime of the tap changer. If the motor drive's contact of the tap changer is also detected, you can select a small value for the software filtering time.

In case of a failure or a loss of tap-changer information, for example, in case of an inadmissible combination of values of the tap-changer position, the I-DIFF stage of the differential protection is blocked. The I-DIFF fast stage remains active.

If the phase-angle regulating transformer is equipped with a tap changer for the in-phase regulation in addition to the phase-angle regulation or quadrature regulation, you can consider both tap changers in the differential protection.

AR Switch

The Advanced Retard Switch (AR switch) toggles the direction of the no-load phase displacement without interruption of the load current.

With the Use AR switch parameter in the Phase shifter function block, you determine how the differential protection responds when changing the AR switch.

In order to prevent an overfunction of the transformer differential protection, blocking of the transformer differential protection is adjustable. The blocking must be selected for the time that is required by the AR switch to reach a new position. Blocking applies only to the I-DIFF stage. The I-DIFF fast stage is not blocked.

6.3.3 Application and Setting Notes for the Single-Core PST

The following text describes the settings required for the application of the differential protection for the phase-angle regulating transformer of the single-core transformer type. You can find the general setting information for the transformer differential protection in chapter 6.2.4 Application and Setting Notes.

Transformer Side Function Group

After the instantiation of the Single-core PST function block, additional parameters for the setting of the tap changers are displayed.

> **NOTE**
> Ensure that the correct transformer data are set at the measuring points.

> **NOTE**
> Consider that only one tap changer can be parameterized on one transformer side.

Parameters for the Tap Changer Transformer with In-Phase Regulation

In the Transformer side function group, to set the tap changer, enter the following settings for the tap changer transformer with in-phase regulation.

Parameter: Tap changer

- Default setting (_:91:44) Tap changer = none

With the Tap changer parameter, you assign a tap changer to the transformer side. The tap changer is used to detect the in-phase regulation. If a tap changer is assigned, other parameters also become visible. You can use a separate tap changer or the tap changer in the voltage controller.

Parameter: Basic position

- Default setting (_:91:138) Basic position = 8

With the Basic position parameter, you determine the position of the tap changer for the in-phase regulation at which the transformer operates at the rated voltage.

Parameter: Volt. diff. adjacent taps

- Default setting (_:91:139) Volt. diff. adjacent taps = 0.000 kV

With the Volt. diff. adjacent taps parameter, you set the voltage difference of a stage under open circuit conditions.

Parameters for the Phase-Angle Regulating Transformer Tap Changer

In the Transformer side function group, to set the tap changer, enter the following settings for the tap changer phase-angle regulating transformer.

Parameter: Tap changer

- Default setting (_:91:45) Tap changer = none

With the Tap changer parameter, you assign a tap changer to the transformer side. This tap changer is used to detect the phase-angle regulation.

> **NOTE**
> You must parameterize this tap changer when using the application phase-angle regulating transformer of the single-core PST type.

Parameter: Table of Angles

Table of angles			
911.91.165	Table of angles:	Pos[]	Angle[°]
		1	0.000
		2	0.000
		3	0.000
		4	0.000
		5	0.000

Figure 6-52 Table Display of the Angles in DIGSI

Parameter: Table of Voltages

Table of voltages			
911.91.166	Table of voltages:	Pos[]	Vtg [kV]
		1	0.000
		2	0.000
		3	0.000
		4	0.000
		5	0.000

Figure 6-53 Table Display of the Voltages in DIGSI

Transformer Differential Protection Function Group

In the Transformer differential protection function group, in the Single-Core PST function block, enter the following settings.

Parameter: Use AR switch

- Default setting (_:101) Use AR switch = no

With the Use AR switch parameter, you determine whether the differential protection considers the switching of the AR switch. When using the setting Block function, the parameter (_:102) Blocking time ARS is visible.

Parameter: Blocking time ARS

- Default setting (_:102) Blocking time ARS = 12.00 s

With the Blocking time ARS parameter, you determine how long the I-DIFF stage of the differential protection will be blocked during the switchover of the AR switch. This blocking function is necessary in order to avoid an overfunction of the differential protection. In order for the AR switch to reach its new position safely, you must select a sufficient blocking time.

> **NOTE**
> If you have assigned a transformer neutral point to a grounded side with a user-defined vector-group number, Siemens recommends not to use the measured 1-phase current of the neutral point in the differential-protection calculation.

Example:

Transformer example: Single Core PST 90°
Information provided by the manufacturer:

Type:	Three-legged core with stabilizing winding. The stabilizing winding cannot be accessed from the outside.
Power:	200 MVA
Rated voltages:	110 kV/110 kV ±10° (± 13 stages)
Frequency:	50 Hz
Phase angle:	No-load state: ±10° (position 1 = -10°, position 14 = 0°, position 27 = +10°)
	Full load: position 1 = -13°, position 14 = 2,6°, position 27 = +7°)

Stage	Open-Circuit Phase Angle [°]	Open-Circuit Output Voltage [kV]
1	-10,00°	111,70 kV
2	-9,24°	111,45 kV
3	-8,49°	111,22 kV
4	-7,72°	111,01 kV
5	-6,96°	110,82 kV
6	-6,19°	110,63 kV
7	-5,42°	110,49 kV
8	-4,65°	110,34 kV
9	-3,88°	110,25 kV
10	-3,11°	110,16 kV
11	-2,33°	110,09 kV
12	-1,55°	110,04 kV
13	-0,78°	110,01 kV
14	0,00°	110,00 kV
15	0,78°	110,01 kV
16	1,55°	110,04 kV
17	2,33°	110,09 kV
18	3,11°	110,16 kV
19	3,88°	110,25 kV
20	4,65°	110,34 kV
21	5,42°	110,49 kV
22	6,19°	110,63 kV
23	6,96°	110,82 kV
24	7,72°	111,01 kV
25	8,49°	111,22 kV
26	9,24°	111,45 kV
27	10,00°	111,70 kV

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Parameterization of the function block:

- Set the parameters for a 2-sided transformer (for example, with the application template: two-winding transformer, basic)
- Set the parameters for the tap changer
- Set the parameters for the Single-core PST function block in the current Transformer differential protection function group

Tap-changer settings:

- Set the required motor monitoring time of the motor function. The setting for the highest tap changer position is not required for the quadrature regulation tap changer; in this case, the tap changer is not considered.
- You set the additional settings for the tap changer in the information routing found in the Properties dialog for the tap changer position. To adjust the settings, follow the information of the manufacturer. These settings include:
  - Offset of the tap display: 6
  - Number of tap positions: 27
  - Tap coding type: Binary
  - Motor run signal: Activate the detection of the motor run signal if this signal is available
  - Software filtering time: Set the software filtering time on the basis of the runtime needed by the tap changer to change the position from one stage to the adjacent stage.
- Route the position of the tap changer to the corresponding binary inputs.

Settings for the transformer sides:

- Set the rated data of transformer side 1 according to the documentation of the manufacturer:
  - Rated apparent power: 200 MVA
  - Rated voltage: 110 kV
  - Vector group number: 0
- Set the rated data of transformer side 2 according to the documentation of the manufacturer:
  - Rated apparent power: 200 MVA
  - Rated voltage: 110 kV
- Set the parameters of the tap changer as a quadrature-regulation tap changer. Subsequently, the tables for the positions, angles, and voltages settings become visible.
- Set the angles and the voltages of the individual stages of the tap changer according to the table in the documentation of the manufacturer.

Settings for the transformer differential protection:

- Set the Single-core PST function block:
  - Use switch: No

For phase-angle regulating transformers of the Single-core type, the setting can be selected frequently. Since switching can occur without interruption at 0°.

6.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Tap changer				
_:91:138	General:Basic position		-126 to 127	6
_:91:139	General:Volt. diff. adjacent taps		0.000 kV to 800.000 kV	0.000 kV

Addr.	Parameter	C	Setting Options	Default Setting
_:91:44	General:Tap changer		Setting options depend on configuration	
_:91:45	General:Tap changer		Setting options depend on configuration	
Single-core PST				
_:101	Single-core PST:Use AR switch		• no • Block function	no
_:102	Single-core PST:Blocking time AR5		0.00 s to 60.00 s	12.00 s

6.3.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:99	Single-core PST >AR switch	SPS	I

6.3.6 Phase-Angle Regulating Transformers of the Type Special Transformer

The term special transformer refers to industrial-type transformers. Their windings are interconnected in such a way that a phase displacement that is different than 30°, for example ±2.5°, is possible. Special transformers can be used, for example, to supply power to electrical drives, frequency converters, and rectifiers. When joining the rectified currents from several windings with shifted phase displacements, the result is reduced ripple of the direct current.

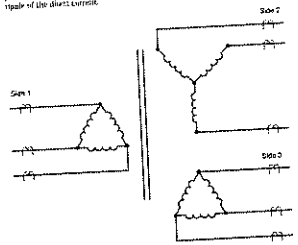

Figure 6-54 Basic Scheme of a Special Transformer

Configure the differential protection for the special transformers by adding the Special transformers function block to the Transformer differential protection function.

- Transformer side 1
- Transformer side 2
- Transformer diff. 1
  - Special transf.
  - 87T diff. prot. 1
  - Circuit-breaker interaction
- Circuit breaker 1
- Circuit breaker 2

Figure 6-55 Instance of the Special Transformer Function Block

After instantiation of the Special transformers function block in the Transformer differential protection function group, the setting range of parameter (_:91:163) Vector group numeral is extended by the user-defined setting in the assigned Transformer side function group. If you select this setting option, the additional parameter (_:91:162) Phase shift is displayed. You can set this parameter in a range of values from -180.000° to +180.000°. The Special transformers function block has no own settings.

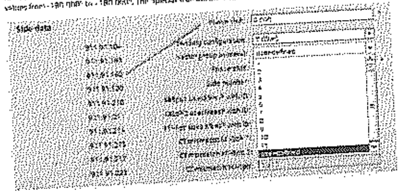

Figure 6-56 Settings for the Transformer Side

You can combine the special transformer and a transformer with in-phase regulation for adaptive adjustment of the transformer differential protection.

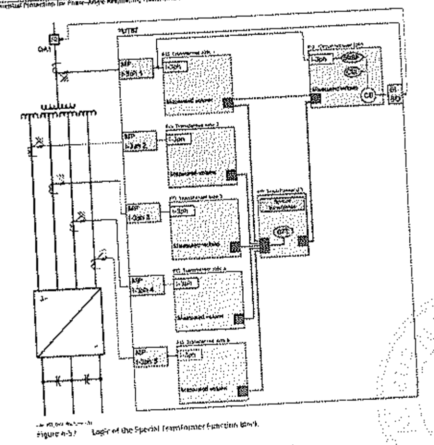

Figure 6-57 Logic of the Special Transformer Function Block

6.3.7 Application and Setting Notes for the Special Transformer

The following text describes the settings required for the application of the differential protection for the phase-angle regulating transformer of the special transformer type. You can find the general setting information for the transformer differential protection in chapter 6.2.4 Application and Setting Notes

Parameter: (_:91:163) Vector group numeral

- Default setting Vector group numeral = 0

With the Vector group numeral parameter, you set the vector-group number of the transformer side. To use special transformers, select the user-defined setting. If you select this setting, the parameter (_:91:162) Phase shift is displayed.

Parameter: (_:91:162) Phase shift

- Default setting Phase shift = 0

With the Phase shift parameter, you set the phase displacement of the transformer side.

NOTE

If you have assigned a transformer neutral point to a grounded side with a user-defined vector-group number, Siemens recommends not to use the measured 1-phase current of the neutral point in the differential protection calculation.

6.3.8 Settings

Addr.	Parameter	C	Setting Options	Default Setting
_:91:104	General:Winding configuration		• Y (Wye) • D (Delta) • Z (Zig-Zag)	Y (Wye)
_:91:163	General:Vector group numeral		• 0 • 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • 10 • 11 • user-defined	0
_:91:162	General:Phase shift		-180.000° to 180.000°	0.000°

6.3.9 Phase-Angle Regulating Transformers of the Type Two-Core PST

The phase-angle regulating transformer of the two-core transformer type (Two-Core PST) consists of a 3-phase series transformer and a 3-phase exciting transformer. The voltage generated by the exciting transformer can be set as a series voltage ΔV and can be coupled to the delta winding of the series transformer. Series and exciting transformers can be integrated in a single tank or in separate tanks.

A protection system with 2 differential protection functions has established itself for the differential protection of these transformers (see IEC 62032:2012 and IEEE Std C57.135):

- Primary differential protection (ANSI 87P)
- Secondary differential protection (ANSI 87S)

For this protection system, the connections of 4 current measuring points are required. Connect these points with 4 transformer sides.

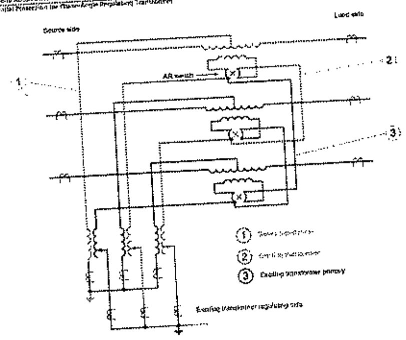

Figure 6-58 Symmetrical Two-Core Transformer Scheme, Two-Core PST

Configure the differential protection for the phase-angle regulating transformers by adding the Two-core PST function block to the Transformer differential protection function.

- Transformer side 1
- Transformer side 2
- Transformer side 3
- Transformer side 4
- Transformer diff. 1
  - Two-core PST
  - 87T diff. prot. 1
  - 87T diff. prot. 2
  - Circuit-breaker interaction
- Circuit breaker 1
- Circuit breaker 2

Figure 6-59 Instance of the Two-Core PST Function Block

After instantiation of the Two-core PST function block, additional parameters are displayed on the transformer sides. With the (_:91:167) Two-core side type parameter, you determine the type of the side.

6.75

All 4 sides of the phase-angle regulating transformer must be of different types. This is tested when setting the transformer sides.

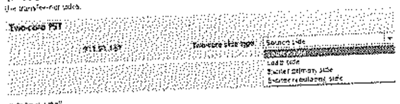

Figure 6-60 Setting the Transformer Sides

NOTE

Parameterization of the tap changer is not required for the application Two-Core PST phase-angle regulating transformer application. Therefore, you must set the parameter Tap changer to No.

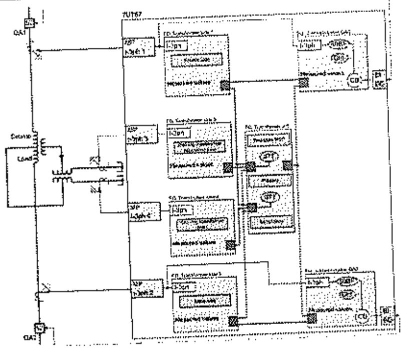

Figure 6-61 Logic of the Two-Core PST Function Block

AR Switch

The Advanced Retard System (AR switch) toggles the direction of the no-load phase displacement without interruption of the load current.

With the Use AR switch parameter in the Phase shifter function block, you determine how the differential protection responds when changing the AR switch.

In order to prevent an overfunction of the transformer differential protection, blocking of the transformer differential protection is adjustable. The blocking must be selected for the time that is required by the AR switch to reach a new position. Blocking applies only to the I-DIFF stage. The I-DIFF fast stage is not blocked.

In addition to blocking the differential protection functions, a further switchover of the vector group number (0 and 6) can be required. This is necessary when positioning the switch in the triangle of the delta winding, since the direction of the electric current in the measuring points of the excitation winding (regulating side) is inverted.

6.3.10 Application and Setting Notes for the Two-Core PST

The following text describes the settings required for the application of the differential protection for the phase-angle regulating transformer of the two-core transformer type. You can find the general setting information for the transformer differential protection in chapter 6.2.8 Application and Setting Notes.

You cannot combine the Two-Core PST with a transformer with in-phase regulation for adaptive adjustment of the transformer differential protection.

Transformer Side Function Group

After the instantiation of Two-core PST function block, additional parameters for the setting of the tap changers are displayed.

Go to the Transformer Side function group and make the following settings.

NOTE

Ensure that the correct transformer data are set at the measuring points.

Parameter: Two-core side type

- Default setting (_:91:167) Two-core side type = Source side

With the Two-core side type parameter, you set the following side types: Source side, Load side, Exciter primary side and Exciter regulating side.

To use the phase-angle regulating transformer of the two-core transformer type with both protection functions 87T primary and 87T secondary, all 4 sides are required.

The tap-changer position information is not required for the protection scheme.

NOTE

The setting of the neutral-point grounding is not available, since it must not be changed in this protection scheme (see IEC 62032 / IEEE Std C57.135). The appropriate values are used in the device in accordance with the type of side.

The settings of both parameters Rated apparent power and Rated voltage on the exciting-unit side do not affect the differential protection. In order for them to function correctly, they must be derived in the device from the information received from the other sides. However, these settings may be required for additional but only side-relevant protection functions.

Parameter: (_:91:163) Vector group numeral

- Default setting Vector group numeral = 0

The Vector group numeral parameter is only visible and required for the regulating side of the exciting transformer. This setting is applicable for the forward direction of the switch when setting the parameter Use AR switch = Block fct. & switch VG. If another setting is select, the parameter applies in both switch positions.

Transformer Differential Protection Function Group

A phase-angle regulating transformer of the Two-Core PST type can only be protected completely by using 2 differential protection functions. To do this, instantiate the function 87T twice in the Transformer differential protection function group.

In the Transformer differential protection function group, make the following settings.

Parameter: Diff. function mode

- Default setting (_:7311:188) Diff. function mode = 87T primary prot

With the Diff. function mode parameter, you assign an operating mode to the differential protection.

Parameter Value	Description
87T primary prot	In the primary protection operating mode, this protection function uses primarily the source side, load side, and the exciting-transformer primary side. The regulating side of the exciting transformer is ignored.
87T secondary prot	In the secondary protection operating mode, this protection function preferably uses the source side, the load side, and the regulation side of the exciting transformer. The primary side of the exciting transformer is ignored.

Parameter: Series unit ratio

- Default setting (_:2311:109) Series unit ratio = 1.000

With the Series unit ratio parameter, you set the winding number ratio of the series transformer:

$$K = \frac{n_{Source} + n_{Load}}{n_{Reg}}$$

You can also generate this ratio with the information about the no-load voltage of the windings.

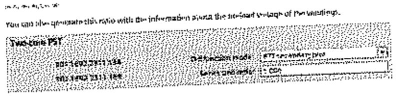

Figure 6-62 Setting the Winding Ratio in DIGSI

Two-Core PST Function Block

In the Transformer differential protection function group, in the Two-core PST function block, make the following settings:

Parameter: Use AR switch

- Default setting (_:101) Use AR switch = no

With the Use AR switch parameter, you define whether the differential protection considers the switch-over of the AR switch.

Parameter Value	Description
no	No consideration of the AR switch

Parameter Value	Description
Block function	During AR switchover, the stage I-DIFF differential protection is blocked.
Block fct. & switch VG	During AR switchover, the stage I-DIFF differential protection is blocked, and the vector group of the regulating side of the exciting transformer is switched internally.

Figure 6-63 Setting the AR Switch in DIGSI

When installing the switch in the triangle of the delta winding, the direction of the current in the measuring points of the excitation winding (regulating side) is inverted. Therefore, you must also switch the vector-group number (0 or 6).

When the switch changes the activation of the excitation winding (regulating side), the current through the measuring point on this side does not change in most cases. This depends on the installation location of the transformer. In this case, you can set the parameter Use AR switch to No. If you still face short-term differential current during the switchover phase, you can use the Block function setting to avoid an unwanted tripping of the 87T secondary function.

If you set the parameter Block function or Block fct. & switch VG, the parameter (_:102) Blocking time ARS becomes visible. You can use this parameter to set the blocking time of the I-DIFF stage of the transformer differential protection 87T secondary. During the blocking time, the stage switches to the not active condition. If the switch has not reached a valid position after the time has elapsed, the I-DIFF stage switches to the Alarm condition. In this condition, you must route the input signals of the switch. Since the protection must block immediately, no software filtering time is available for the switch. The blocking time is not triggered.

The transformer differential protection 87T primary remains unaffected by these parameters.

In order to ensure the proper detection of the AR switch condition by the binary inputs >Switch, a connection as double-point indication is provided. This will detect and report intermediate positions and disturbed positions. If only one binary input is available, you can proceed with the conversion in the CFC by using the Build_DSP converter building block. The DSP position closed indicates a forward direction. The DSP position open indicates a reverse direction.

Parameter: (_:102) Blocking time ARS

- Default setting Blocking time ARS = 12.00 s

With the Blocking time ARS parameter, you determine how long the I-DIFF stage of the differential protection will be blocked during the switchover of the AR switch. This time is necessary in order to prevent an overfunction of the differential protection. In order for the AR switch to reach its new position safely, you must select a sufficient blocking time. Typically, this time is 12 s.

Example:

Transformer example Two-Core PST	
Information provided by the manufacturer:	410 kV/1200 MVA
Rated voltage/rated power	50 Hz
Frequency:	±32 stages
Number of tap positions:	2x 41.1 kV
Rated voltage of the winding parts source side/load side of the series transformer:	105.8 kV
Rated voltage of the secondary winding of the series transformer:	410 MVA
Output of the exciting transformer:	

Rated voltage of the primary excitation winding: 410 kV
Rated voltage of the control winding: 105.8 kV

The AR switch toggles the forward and reverse direction of the delta winding (secondary winding) of the series transformer. Therefore, you must switch the vector group of the regulating side of the exciting transformer between the vector-group number 0 and 6.

Parameterization of the function block:

- Set the parameters for a 4-sided transformer, for example, with the application template for a three-winding transformer as basis and extend it.
- Set the parameters for the Two-core PST function block in the current Transformer differential protection function group.
- Set the parameters for a second differential protection function in the Transformer differential protection function group.
  Capturing the information for the tap changer is not required for the protection scheme.

Settings for the transformer sides:

- Transformer side 1:
  - Two-core side type: Source side
  - Rated apparent power: 1200 MVA
  - Rated voltage: 410 kV
- Transformer side 2:
  - Two-core side type: Load side
  - Rated apparent power: 1200 MVA
  - Rated voltage: 410 kV
- Transformer side 3:
  - Two-core side type: Primary exciting transformer
  - Rated apparent power: 410 MVA (affects only the reference-side selection in the differential protection)
  - Rated voltage: 410 kV (affects only the reference-side selection in the differential protection)
- Transformer side 4:
  - Two-core side type: Shunt-transformer regulating side
  - Rated apparent power: 410 MVA (does not affect the differential protection)
  - Rated voltage: 105.8 kV (does not affect the differential protection)
  - Vector-group number: 0 (information about the vector group number for the forward direction)

Settings for the transformer differential protection:

- Function block Two-core PST:
  - Parameter (_:101) Use AR switch = Block fct. & switch VG
  - Parameter (_:102) Blocking time ARS = 12 s
  If the AR switch leaves its position, the I-DIFF stage of the differential protection will be blocked for the set time. If the AR switch has not reached a valid position after the time has elapsed, the function switches to the Alarm condition.
- Transformer differential protection 1:
  - Operating mode Diff: 87T Primary protection
- Transformer differential protection 2:
  - Operating mode Diff: 87T Secondary protection
  - Series transformer ratio: 0.777 (2 x 41.1 kV/105.8 kV)

- Information routings:
  - Route the binary input signals >Switch.
    Since the protection must block immediately, no software filtering time is available for the switch. The blocking time is not triggered.

6.3.11 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Side data				
_:91:104	General:Winding configuration		• Y (Wye) • D (Delta) • Z (Zig-Zag)	Y (Wye)
_:91:163	General:Vector group numeral		• 0 • 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • 10 • 11 • user defined	0
_:91:162	General:Phase shift		-180.000° to 180.000°	0.000°
Two-core PST				
_:91:167	General:Two-core side type		• Source side • Load side • Exciter primary side • Exciter regulating side	Source side
_:101	Two-core PST:Use AR switch		• no • Block function • Block fct. & switch VG	no
_:102	Two-core PST:Blocking time ARS		0.00 s to 60.00 s	12.00 s
_:7311:188	General:Diff. function mode		• 87T primary prot • 87T secondary prot	87T primary prot.
_:2311:109	General:Series unit ratio		0.001 to 100.000	1.000

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6.4 Restricted Ground-Fault Protection

6.4.1 Overview of Functions

The Restricted ground-fault protection function (ANSI 87N):

- Detects ground faults in transformers, shunt reactors, neutral reactors or rotating machinery in which the neutral point is grounded
- Has high sensitivity to ground faults near the neutral point
- Is supplemental main protection to longitudinal differential protection
- Protects grounding transformers in the protection range. It is required that a current transformer be used in the case of neutral point feed, that is, between neutral point and grounding conductor. The neutral-point transformer and the phase-current transformer define the protection range
- Adapts itself to the highest-amperage side with auto transformers and thereby prevents overfunction in the event of external ground faults

6.4.2 Structure of the Function

The Restricted ground-fault protection function is used in the Transformer side or Auto transformer protection function group. Furthermore, you can use the function in the stabilizing winding of the auto transformer or also in the Standard 1/3 function. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The Restricted ground-fault protection function is shown:

Figure 6-64 Structure/Embedding of the Function

6.4.3 Function Description

Logic of the Function

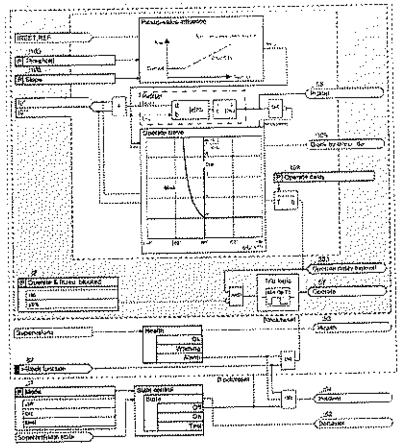

Figure 6-65 Logic Diagram of the Restricted Ground Fault Protection Function

The protection function processes the neutral-point current I_0^* (exactly $3I_0$) and the calculated zero-sequence current I_0^{**} (exactly $3I_0$) from the phase currents (see following figures). The protection range extends exclusively over the transformer winding, including current transformer. The amount adapted (compensated) currents are described by the * icon. They are normalized to the rated object current of the respective side. In case of an internal ground fault, the residual currents flow to the fault location. With an external ground fault, the fault current inverts itself in the phase current transformers. In this way, the direction of current flow serves as the decisive criterion for an internal fault.

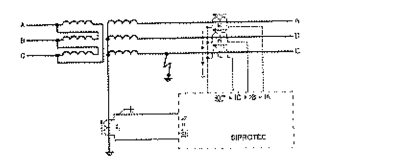

Figure 6-66 Basic Principle of the Function

In accordance with the logic diagram, Figure 6-65 the protection function consists of 4 parts.

Effect of Pickup Value

The differential current and the restraint current are calculated from the residual currents. The reference arrows are defined as positive when pointing to the protected object (see Figure 6-66). Consider that the ground current in the fault record and in the DIGSI 5 Test Suite are displayed as positive if the current flows to ground from the protected object.

> **NOTE**
>
> The following calculation applies to the configurations with a current transformer for the side. In a special case of several current transformers per side, the calculation of the restraint current must be performed in greater detail.

$I_0^* = k_0 \cdot 3I_0'$

$I_0^{**} = k_0 \cdot 3I_0'' = 3I_0'' = I_A + I_B + I_C$

with $k_0 = I_{prim,transf} / I_{rated,side}$

$I_{diff,REF} = |I_0^* + I_0^{**}|$

$I_{rest,REF} = |I_0^*| + |I_A| + |I_B| + |I_C|$

where:

$3I_0'$	Measured zero sequence current at neutral point
$3I_0''$	Zero-sequence current calculated from the phase currents
k_0	Factor for amount adaptation (compensation)
$I_{prim,transf}$	Primary transformer rated current
$I_{rated,side}$	Primary rated current of the transformer side
$I_{diff,REF}$	Differential current
$I_{rest,REF}$	Restraint current

Using the calculated restraint current, a current $I_{rest,REF}$ which represents the pickup value for the tripping is determined from the characteristic curve (Figure 6-67). In this way, the protection function is stabilized in the event of external, multiphase ground faults, for example, a 2-pole ground fault. This means that the protection function becomes less sensitive.

If the Slope = 0 is set here, the set Threshold of the operate curve is delivered independent of the restraint current.

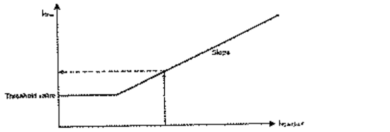

Figure 6-67 Stabilized Characteristic Curve

Processing a Ground Side for Auto Transformer

Instead of a 1-phase neutral point, with an auto transformer a 3-phase ground side can also be used.

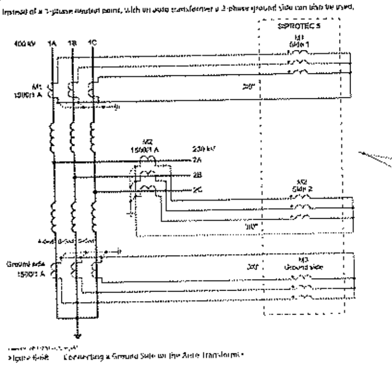

Figure 6-68 Connecting a Ground Side on the Auto Transformer

In this case the neutral-point current calculates as sum of the phase currents of the ground side:

$I_0^* = k_0 \cdot 3I_0' = 3I_0' = I_{phA} + I_{phB} + I_{phC}$

with $k_0 = I_{prim,transf} / I_{rated}$

The following applies for the restraint current:

The following applies for the restraint current $I_{rest,REF} = |I_{0,side}| + |I_{A}| + |I_{B}| + |I_C| = |I_0^*| + |I_0|$ [illegible]

> **NOTE**
>
> If both 1-phase neutral point and 3-phase ground side are connected, only the 1-phase neutral point is used by the restricted ground-fault protection. The 3-phase ground side is not considered.

Pickup

If the $I_{diff,REF}$ calculated differential current exceeds the $I_{rest,REF}$ calculated current (see Figure 6-65), pickup occurs and the internal processing is enabled. The pickup is indicated.

Operate Curve

The operate curve represented in the following figure consists of 2 parts. In the right part of the characteristic curve, you will find a case of an internal ground fault. Under ideal conditions, the angle between the two residual currents ($\angle(I_0^*, I_0^{**})$) equals 0. With current-transformer saturation, angle errors can result. The right part of the characteristic curve is valid for angles ≤ 90°. The tripping current is the current flowing at the neutral point (I_0^*). It is compared to the set or increased threshold value.

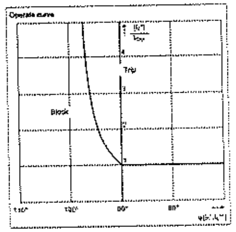

Figure 6-69 Operate Curve Depending on the Phase Angle between I_0^* and I_0^{**} at $|I_0^*| = |I_0^{**}|$ (180° = External Fault)

In case of an external ground fault the zero-sequence current calculated from the phase currents reverses by 180°. The phase angle between the residual currents thus ($\angle(I_0^*, I_0^{**})$) equals 180°. They are located in the left part of the operate curve and recognize a clearly increased pickup value. Angle deviations of 180° are caused by transformer saturation in conjunction with external short-circuits.

The current $I_{rest,REF}$ for the Angle Decision is determined from the following subtraction and summation:

$I_{rest,REF} = |I_0^* - I_0^{**}| - |I_0^* + I_0^{**}|$

The resulting current $I_{rest,REF}$ results from the respective fault conditions, which are illustrated in the following figure. With an internal fault (angle = 0°) a current results that has a negative sign. If angle errors occur, the sign remains negative. The amount of the current decreases.

In an external short-circuit (180°), the current becomes positive. At a smaller angle (<180°) due to transformer saturation, the angle remains positive. The amount also decreases.

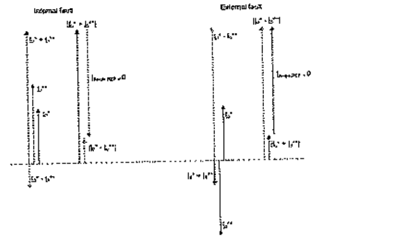

Figure 6-70 Angle Decision in Internal and External Faults

For tripping to occur, the neutral-point current I_0^* must reach the value $I_{rest,REF}$. The characteristic curve in the left part of the figure can be determined from the following relationship:

$I_{rest,REF} = I_{pickup} + k \cdot I_{rest,REF}$

where:

I_{pickup}	Pickup value resulting from the pickup value increase
k	Factor (permanently set to 4 [illegible]. With this value, the limit angle at $|I_0^*| = |I_0^{**}|$ is precisely 100°. No tripping is possible from this angle on.)

Processing of Several Measuring Points on One Side

If several measuring points are present on one side of a transformer winding, as with a 1 1/2 circuit-breaker application, the angle decision occurs separately for each measuring point. The maximum current $I_{rest,REF}$ is used to establish the tripping decision.

> **NOTE**
>
> With an external fault, the current $I_{rest,REF}$ is always > 0.

The following figure shows the behavior under different fault conditions.

Also observe that the restraint current ($I_{rest,REF}$) always results from the sum of all current absolute amounts of the measuring points and the neutral-point current. For pickup, the differential current $I_{diff,REF}$ is necessary. This differential current results from the geometric sum of all adapted residual currents. The residual currents of the measuring points on the outgoing side and of the neutral-point current are shown here.

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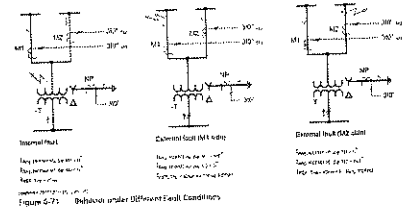


Figure 6-71 Behavior under Different Fault Conditions

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion
(_:313) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF
(_:312) I angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF
(_:301) I diff.	Differential current
(_:302) I restr.	Restraint current

You will find the measured values for the **Restricted ground-fault protection** under the following device menu entries:

- Main menu → Measurements → Function → Function values → 87N REF

6.4.4 Application and Setting Notes

NOTE

The following conditions must be observed when setting the threshold values:

Threshold value ≥ max {0.05 I/Irated,O; 0.05 I/Irated,S · $I_{\text{prim,rated,max}}$ / $I_{\text{prim,neutral point}}$}

Threshold value ≤ min {2.00 I/Irated,O; 200.00 I/Irated,S · $I_{\text{prim,rated,max}}$ / $I_{\text{prim,neutral point}}$}

The value 0.05 I/Irated,O is the minimum possible setting value and 2.00 I/Irated,O the maximum possible. $I_{\text{prim,rated,max}}$ is the largest transformer current and $I_{\text{prim,neutral point}}$ the protected object rated current. 200.00 I/Irated,S is the upper measurement limit.

If otherwise it could happen that there is chattering of the pickup indication, the minimum threshold limit is lifted. The maximum limit on the other hand is corrected downward, if the restraining current otherwise through the magnitude scaling must be so large that it would already be outside of the measuring range of the transformer.

The adaptation of the setting limits is done automatically. In addition a setting is prevented outside of these limits.

In the following, typical applications are described for the restricted ground-fault protection 87N.

Protection of a Solidly Grounded Star Winding (Y Side)

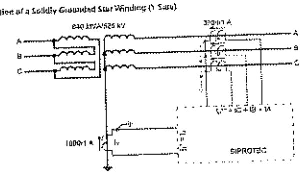


Figure 6-72 Application Star Side

This application is a standard application. Here the phase currents of one side and the neutral-point current are processed. The function is located in the Transformer Side function group.

The following figure shows the structural division of the function. The restricted ground-fault protection gets its measurands from the current transformers, which are connected to the Transformer side function group. The neutral point current is guided via the Transformer neutral point function group to the Transformer side function group. To be compatible with SIPROTEC 4 (including reference arrow definition of the restricted ground-fault protection), in addition to the magnitude scaling of the neutral-point current, a rotation of the polarity (phase rotation by 180°) is also done in the Transformer neutral point function group.

NOTE

The fault record indicates the analog traces according to the connection. For this reason the neutral-point current is shown rotated by 180° in comparison to SIPROTEC 4.

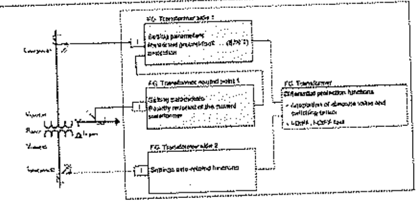
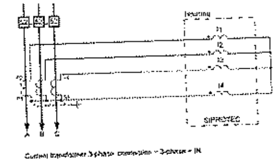


Figure 6-73 Function Group Structure of the Restricted Ground-Fault Protection

Explanations on the Connection and Current-Direction Definition

Uniform reference arrows and transformer directions are defined for the SIPROTEC 5 device series. These agreements also apply to the transformer protection devices. The special handling of the neutral point current described previously is a result of this.

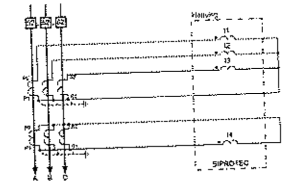
The current definition states that the sum of the currents flowing into the protected object is equal to 0 (I_A + I_B + I_C = 0 or I_A + I_B + I_C = $-I_N$). The protected object is located to the right or left of the transformer set. The following basic connections result from this.



Current transformer 3-phase, connection = 3-phase + IN

Figure 6-74 Current Transformer Connection (1) According to Definition

or



Current transformer 3-phase, connection = 3-phase + IN-separate

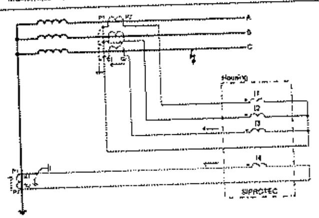
Figure 6-75 Current-Transformer Connection (2) According to Definition

The following connection is defined for the transformer according to Figure 6-76. The current flow for an external ground fault is entered at the same time. It is recognized that the secondary currents each flow from the device. From this, a differential current ($I_{\text{diff,REF}}$ = I_A + I_B + I_C + I_N ...) results, according to the reference arrow definition for the restricted ground-fault protection (positive to the protected object) with an

external ground fault. To prevent that, the neutral-point current is rotated in the Transformer neutral-point function group. It follows that $I_{\text{diff,REF}}$ = $|I_N - I_N|$ = 0.

NOTE

If the neutral-point current is included in the protection function (zero-sequence current correction), this rotation also has an effect for the differential protection.



Current transformer 3-phase, connection = 3-phase

Current transformer 1-phase, connection = IN

Figure 6-76 Current Transformer Connection on the Transformer

The setting of the 1-phase measuring point based on the definition is done as follows:

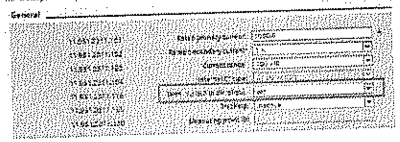


Figure 6-77 DIGSI 5 Setting

The point in Figure 6-76 describes the polarity of the current transformer. At the same time the current terminal is designed so that this side is fed out on an odd number terminal point. Since in the SIPROTEC 5 system each current transformer can be assigned a 1-phase measuring point, the odd number terminal points are named in the setting parameters. According to Figure 6-76 the setting must be yes.

- Default setting (_:115) Terminals 1,3,5,7 in dir. obj. = yes

The following view can be used to derive the threshold value. The transformer is supplied, for example, via the delta winding and a 1-pole ground fault occurs on the star side.

NOTE

For estimation of the short-circuit current, note that the inductance changes quadratically with the winding and the linearly with the voltage.

The right part in the following figure represents the fault current as a function of the fault location. The fault current curve shows that the longitudinal differential protection with faults near the neutral point has sensitivity problems due to the striking current. On the other hand, the neutral point current is sufficiently large. There is therefore no need to set the Threshold (current through the neutral point transformer) to sensitive.

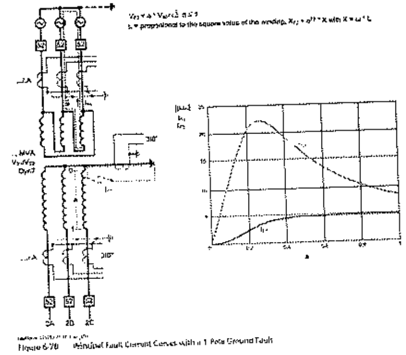


Figure 6-78 Residual Fault Current Curves with a 1-Pole Ground Fault

- Recommended setting value (_:103) Threshold = 0.2 I/Irated,S

The previously mentioned condition must be maintained during the setting.

Threshold value ≥ 0.05 Irated,S · $\frac{I_{\text{prim,rated,max}}}{I_{\text{prim,rated}}}$

The following lower limiting value results from the data from Figure 6-72

$$\text{Threshold value} \geq 0.05\ I_{\text{rated,S}} \cdot \frac{3000\,A}{924\,A} = 0.162\ I_{\text{rated,S}}$$

$$\text{with } I_{\text{prim,rated}} = \frac{S_{\text{rated}}}{\sqrt{3}\,V_{\text{rated}}} = \frac{840\,MVA}{\sqrt{3}\,525\,kV} = 924\,A$$

The recommended setting value of 0.2 I/Irated,S lies above it.

- Recommended setting value (_:105) Slope = 0.07

You can stabilize the protection function (less sensitive setting) with external multiphase short-circuits to ground with the parameter Slope. To determine the setting value, no pickup value increase can occur up to the rated current. After this, the gradient must be active. To derive the gradient, it is assumed that continuation of the straight line must go through the coordinate origin (see Figure 6-79). Determine the intersection from the threshold value and the restraint current at rated current. Calculate the gradient as follows.

$$I_{\text{rest,REF}} = |I_A| + |I_B| + |I_C| + 0 = 3\ I_{\text{rated,S}} = 3\ I_{\text{rated,S}}$$

$$\text{Slope} = \frac{\text{Threshold value}}{I_{\text{rest,REF}}} = \frac{0.2\ I_{\text{rated,S}}}{3\ I_{\text{rated,S}}} = 0.07$$

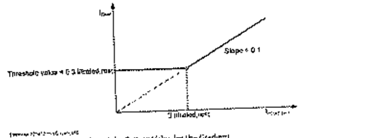


Figure 6-79 Derivation of the Setting Value for the Gradient

If you have several measuring points on an outgoing side (see Figure 6-71), Siemens recommends using the value 3 Irated,S in the intersection calculation for the restraint current. In the load case, the maximum transformer rated current flows on one side.

If, however, several measuring points are on the supply side (for example, breaker-and-a-half layouts), Siemens recommends including all phase currents in the intersection calculation, in order to avoid rate strong of a stabilization. With 2 measuring points, a value of 6 Irated,S results as intersection with the threshold value. The slope becomes flatter (0.2 Irated,S/6 Irated,S = 0.03).

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Protection of an Auto Transformer

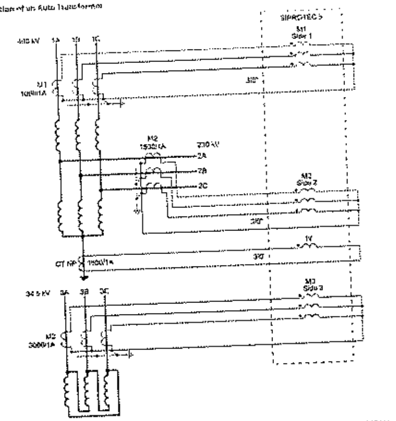

Figure 6-80 Activation and Application Example of an Auto Transformer (500 MVA; 400 kV, 230 kV; 125 MVA; 34.5 kV)

Use the highest side rated current with the auto transformer for normalization. In the example (Figure 6-80), the measuring point is M2 (230 kV side). For this side, a rated current of 500 MVA/(√3 · 230 kV) = 1255 A results. The primary transformer rated current is 1500 A. With this, you can estimate the minimum permissible pickup value.

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{I_{CT,primary}}{I_{rated,side}} = 0.05\ I/I_{rated,S} \cdot \frac{1500\,A}{1255\,A} = 0.06\ I/I_{rated,S}$$

Siemens recommends a setting value of 0.2 I/Irated,S.

- Recommended setting value (_:103) Threshold = 0.2 I/Irated,S

To determine the Slope, the restraint current of both sides (400 kV and 230 kV) must be used. For which current is used as starting value for the gradient. Since side 2 (230 kV) is the reference side for the normalization, the value of the 400 kV side must be adapted to this rated current. The adaptation factor results from the inverse ratio (230 kV/400 kV). The following restraint current goes into the calculation.

$$I_{restREF} = 3\ I/I_{rated,S2} + 3 \frac{230\,kV}{400\,kV}\ I/I_{rated,S2} = 3\ I/I_{rated,S2} + 1.725\ I/I_{rated,S2} = 4.73\ I/I_{rated,S}$$

$$\text{Slope} = \frac{\text{Threshold value}}{I_{restREF}} = \frac{0.2\ I/I_{rated,S}}{4.73\ I/I_{rated,S}} = 0.042$$

Siemens recommends using the setting 0.07.

- Recommended setting value (_:105) Slope = 0.07

Protection of a Resistance-Grounded Star Winding (Y Side)

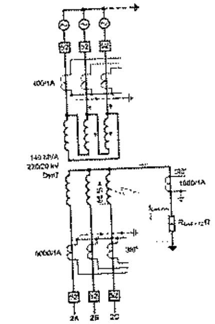

Figure 6-81 Application with Resistance-Grounded Neutral Point

To also capture faults in the resistance to ground, a current transformer must be installed at the neutral point of the protected object (see Figure 6-81). The pickup values can be derived from the data in the example. As side rated value, the following results:

140 MVA/(√3 · 20 kV) = 4042 A

The following threshold value results as lower limit:

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{6000\,A}{4042\,A} = 0.0742\ I/I_{rated,S}$$

$$\text{with } I_{rated,side} = \frac{S_{rated}}{\sqrt{3} \cdot V_{rated}} = \frac{640\,MVA}{\sqrt{3} \cdot 400\,kV} = 924\,A$$

So that the function is responsive, select a setting value of 0.06 I/Irated,S.

- Recommended setting value (_:103) Threshold = 0.06 I/Irated,S

As gradient, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{restREF}} = \frac{0.08\ I/I_{rated,S}}{3\ I/I_{rated,S}} = 0.03$$

- Recommended setting value (_:105) Slope = 0.03

Because of the grounding resistance, a reduced protection range results. This can be estimated as follows. The grounding resistance is much larger than the winding reactance, thus the following maximum ground current results:

$I_{Gnd,max}$ = 20 kV/√3 · 12 Ω = 962 A

You can determine the minimum tripping current from the setting value.

$I_{Gnd,min}$ = side rated current · threshold value = 4042 A · 0.08 = 323 A

Thus, the following protection range results:

$$\text{Protection range} = 1 - \frac{I_{Gnd,min}}{I_{Gnd,max}} = 1 - \frac{323\,A}{962\,A} = 0.664$$

The attainable protection range amounts to approx. 66.4 %. In order to capture ground faults near the neutral point, it is also recommended to connect a sensitive ground current protection to the neutral point transformer. You must coordinate its operate time with the line protection.

NOTE

Ensure that the protection range further limits itself with larger neutral-point resistances, as the restricted ground-fault protection can no longer be used.

Protection with Neutral Reactors on the Delta Side

To produce ground currents on the delta side of a transformer, neutral reactors (zigzag reactors) are used. A resistance for ground current limitation can also be present. In this case, the resistance is much greater than the reactor and delta reactance of the transformer. The following figure shows a typical implementation. The restricted ground-fault protection works between phase-sided phase current transformers and the current transformer in the neutral point of the neutral reactor.

In the example, the fault current curve with the ground fault in a delta winding is also represented. The fault location in which the lowest fault current flows can also be seen. This current influences the protection setting value.

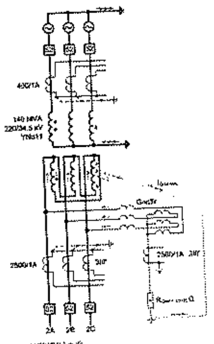

Figure 6-82 Application with Neutral Reactor

As side rated value, the following results:

140 MVA/(√3 · 34.4 kV) = 2343 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.06\ I/I_{rated,S} \cdot \frac{2500\,A}{2343\,A} = 0.05\ I/I_{rated,S}$$

If the fault is in the middle of the winding, the minimum ground current will arise, as shown in Figure 6-82. The driving voltage is:

$V_{driving}$ = V_{rated}/(2 √3) = 34.5 kV/(2 √3) = 9.96 kV

The following minimum ground current results:

$I_{Gnd,min}$ = $V_{driving}$/R_{Gnd} = 9.96 kV/19.05 Ω = 523 A

With reference to the side rated current, the relationship is

$I_{Gnd,min}$/I_{rated} = 523 A/2343 A = 0.223

With a safety margin of 2, 0.223/2 = 0.1115 results. Select this value as threshold value (rounded: 0.12 I/Irated,S).

- Recommended setting value (_:103) Threshold = 0.12 I/Irated,S

As gradient, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{restREF}} = \frac{0.12\ I/I_{rated,S}}{3\ I/I_{rated,S}} = 0.04$$

- Recommended setting value (_:105) Slope = 0.04

Protection at a Shunt Reactor

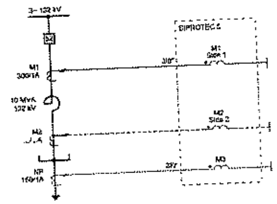

Figure 6-83 Application with Neutral Reactor

As side rated value, the following results:

10 MVA/(√3 · 132 kV) = 43.7 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{300\,A}{43.7\,A} = 0.343\ I/I_{rated,S}$$

Select 0.35 I/Irated,S as threshold value.

- Recommended setting value (_:103) Threshold = 0.35 I/Irated,S

For the shunt reactor, there is no external fault that can lead to overfunction. Siemens recommends a minimum rise (0.05).

- Recommended setting value (_:105) Slope = 0.05

6.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
87N REF #				
_:1	87N REF #:Mode		• off • on • test	off
_:2	87N REF #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:103	87N REF #:Threshold		0.05 I/InObj to 2.00 I/InObj	0.20 I/InObj
_:105	87N REF #:Slope		0.00 to 0.95	0.07
_:100	87N REF #:Operate delay		0.00 s to 60.00 s; ∞	0.00 s
_:101	87N REF #:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:151	87N REF #:MU-ID Side 1 Mp3ph 1		0 to 100	0
_:152	87N REF #:MU-ID Side 1 Mp3ph 2		0 to 100	0
_:153	87N REF #:MU-ID Side 1 Mp3ph 3		0 to 100	0
_:154	87N REF #:MU-ID Side 1 Mp3ph 4		0 to 100	0
_:156	87N REF #:MU-ID Side 2 Mp3ph 1		0 to 100	0
_:157	87N REF #:MU-ID Side 2 Mp3ph 2		0 to 100	0
_:158	87N REF #:MU-ID Side 2 Mp3ph 3		0 to 100	0
_:159	87N REF #:MU-ID Side 2 Mp3ph 4		0 to 100	0
_:161	87N REF #:MU-ID Side 3 Mp3ph 1		0 to 100	0
_:162	87N REF #:MU-ID Side 3 Mp3ph 2		0 to 100	0
_:163	87N REF #:MU-ID Side 3 Mp3ph 3		0 to 100	0
_:164	87N REF #:MU-ID Side 3 Mp3ph 4		0 to 100	0
_:166	87N REF #:MU-ID Side 4 Mp3ph 1		0 to 100	0
_:167	87N REF #:MU-ID Side 4 Mp3ph 2		0 to 100	0
_:168	87N REF #:MU-ID Side 4 Mp3ph 3		0 to 100	0
_:169	87N REF #:MU-ID Side 4 Mp3ph 4		0 to 100	0
_:171	87N REF #:MU-ID Side 5 Mp3ph 1		0 to 100	0
_:172	87N REF #:MU-ID Side 5 Mp3ph 2		0 to 100	0
_:173	87N REF #:MU-ID Side 5 Mp3ph 3		0 to 100	0
_:174	87N REF #:MU-ID Side 5 Mp3ph 4		0 to 100	0
_:185	87N REF #:MU-ID Mp1ph		0 to 100	[illegible]

6.4.6 Information List

No.	Information	Data Class (Type)	Type
87N REF #			
_:82	87N REF #:>Block function	SPS	I
_:54	87N REF #:Inactive	SPS	O
_:52	87N REF #:Behavior	ENS	O
_:53	87N REF #:Health	ENS	O
_:55	87N REF #:Pickup	ACD	O
_:57	87N REF #:Operate	ACT	O
_:303	87N REF #:Operate delay expired	ACT	O
_:305	87N REF #:Block by direct. det.	SPS	O
_:306	87N REF #:I0 REF operate	MV	O
_:307	87N REF #:Angle,REF	MV	O
_:311	87N REF #:I REF,Trip operate	MV	O
_:312	87N REF #:I restr.REF operate	MV	O
_:301	87N REF #:I diff.	MV	O
_:302	87N REF #:I restr.	MV	O

6.5 Motor Differential Protection

6.5.1 Overview of Functions

The Motor Differential Protection function (ANSI 87M)

- Detects ground faults and multiphase short circuits in motors
- Detects ground faults during the operation of motors on systems with a grounded neutral point
- Is stable during startup processes with current-transformer saturation through intelligent saturation recognition methods
- Triggers safely in the case of internal high-current faults through an additional high-current stage

6.5.2 Structure of the Function

The Motor differential protection function is used in the Motor diff protection function group. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The Motor differential protection function consists of the tripping stages Idiff and Idiff fast. The tripping stages can be blocked, in addition you can switch the tripping stages on and off.

In the function group Motor Side:

- The side-related protection settings are performed
- The side-related calculations are performed
- All data (scaling values, detected currents) are relayed to the Motor function group

Motor side-related protection functions can run in the Motor Side function group, for example overload protection, overcurrent protection, etc.

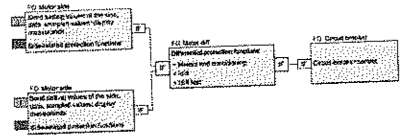

Figure 6-85 Structure/Embedding of the Function

6.5.3 Function Description

Basic Principle of Differential Protection

Differential protection is based on a comparison of currents (Kirchhoff current law). When comparing the currents, use is made of the fact that a protected object ... [illegible] ... The current direction is ... [illegible]

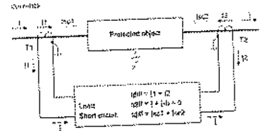

Figure 6-86 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in chapter Differential Protection Function (Idiff), Page 486.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers W1 and W2 ... a corresponding differential current I_{diff} occurs. When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current (I_{rest}) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The derivation for 2 measuring points is:

A sum or differential current is:

$I_{diff} = \underline{I}_1 + \underline{I}_2$

as well as a restraint current of

$I_{rest} = Max(|I_1|; |I_2|)$

For more than 2 measuring points, this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different tripping behavior for internal short circuits.

$I_{rest} = Max(|I_1|; |I_2|; ... |I_n|)$

To clarify the effect, 3 important operating states are observed with ideal and adapted measurands.

- Through flush current in healthy operation or externally caused error: I_1 flows into the protection range, I_2 flows out of the protection range, that is, negative compared with the prefix definition, thus $I_2 = -I_1$

  In addition $|I_2| = |I_1|$

  $I_{diff} = |I_1 + I_2| = |I_1 - I_1| = 0$

  $I_{rest} = Max(|I_1|; |I_2|) = |I_1| = |I_2|$

  No tripping quantity ($I_{diff} = 0$); the stabilization (I_{rest}) corresponds to the flowing current.

- Internal short circuit, feed from both sides with equal amount of currents, for example:

  Then $I_2 = I_1$, in addition $|I_2| = |I_1|$

  $I_{diff} = |I_1 + I_2| = |I_1 + I_1| = 2 \cdot |I_1|$

  $I_{rest} = Max(|I_1|; |I_2|) = |I_1| = |I_2|$

  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the stabilizing quantity (I_{rest}).

- External short circuit, feed only from one side:

  Then $I_2 = 0$

  $I_{diff} = |I_1 + I_2| = |I_1 + 0| = |I_1|$

  $I_{rest} = Max(|I_1|; |I_2|) = |I_1|$

  The tripping quantity (I_{diff}) and the restraining quantity (I_{rest}) are of the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current-transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with Figure 6-86, there are 2 typical scenarios:

- High-current, external short circuit

  First, the current on both sides is transformed and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current I_{rest} drops. Since the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.

- Low current, external short circuit

  Current transformers can also become saturated through the large direct current time constant (switching of transformers, motors), but small currents flowing through. This manifests itself as a phase-angle rotation of the current. Exceeding the characteristic curve in a non-stabilized area is possible.

Intelligent saturation-detection methods capture this state and lead to a temporarily limited blocking of the Differential protection function.

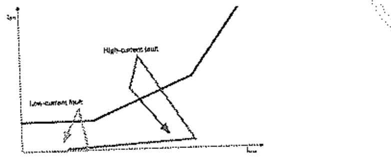

Figure 6-86 Principle Current Curves at External Short Circuit and Temporary Current-Transformer Saturation on One Side

Logic of the Function

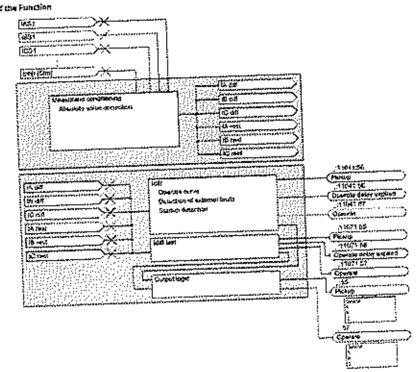

Figure 6-87 Logic Diagram of the Motor Differential Protection Function

In the following, the essential components of differential protection are described in detail.

Measurand Processing

Absolute-Value Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection functions process 20 sampled values per period. In addition, the sampled values tracked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 80 Hz).

The Idiff fast stage works on non-frequency tracked values and thus, implements fast operate times with low measurands.

The absolute value is adapted via the following formula:

$i_{Mod} = k \cdot i_{Meas}$

with $k = \frac{I_{rated,prim,TA}}{I_{rated,obj}}$; $I_{rated,obj} = \frac{S_{rated,ref}}{V_{rated,side} \cdot \sqrt{3}}$

i_{Mod}	Adapted instantaneous value per phase (x = A, B, C)
i_{Meas}	Instantaneous value per phase (x = A, B, C)
k	Correction value per measuring point
$I_{rated,prim,TA}$	Primary transformer rated current per measuring point
$I_{rated,obj}$	Primary rated current of the protected object
$S_{rated,ref}$	Reference power (maximum rated apparent power of the protected object)
$V_{rated,side}$	Rated voltage of the respective side (measuring points of the protected object)

Differential Protection Function (Idiff)

A differential current per phase based on the instantaneous value variables is calculated from the processed currents (see section Measurand Processing). The direction of current flow is defined as to the protected object as positive. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length 1 period (20 sampled values)).

The currents of that measuring point whose RMS value is the largest are used as restraint current. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation, the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

$i_{diff,x,n} = \sum_{m=1}^{N} i_{Mod,x,m} \rightarrow I_{diff,x} = FIR(i_{diff,x,n})$

$I_{RMS,x,m} = \sqrt{\frac{1}{n} \sum_{k=1}^{n} i^2_{Mod,x,m}(k)}$

$I_{rest,x} = \overset{N}{\underset{m=1}{MAX}}(I_{RMS,x,m})$

with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)
FIR	Fourier filter
MAX	Maximum-value determination

Pickup Characteristic

Figure 6-88 shows the pickup characteristic of the differential protection. The characteristic curve branch a represents the sensitivity threshold of the differential protection (parameter Threshold) and considers constant fault currents like magnetizing currents.

The characteristic branch b (parameter Intersection 1 Irest and Slope 1) considers current-proportional faults under normal operating conditions.

These faults can occur for the following reasons:

- Transformation errors in the current transformer and the input transformer of the device
- Adaptation deviations

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The characteristic curve branch (parameter Intersection 2 Iext and Slope 2) protects the differential protection against overfunction in case of high-current external faults and transformer saturation. In this area, transformer saturation can arise due to high short-circuit currents, and because of this, a higher differential current results.

In order to avoid a malfunction in the event of external faults with transformer saturation, a logic is implemented that uses the characteristic curve Additional stabilization of external faults. If the operating point is located in the additional stabilization area and exceeds the operate curve from there, then the logic becomes active and blocks the differential protection.

The additional stabilization range is defined from the Threshold add-on stabiliz. and Slope 1 parameters.

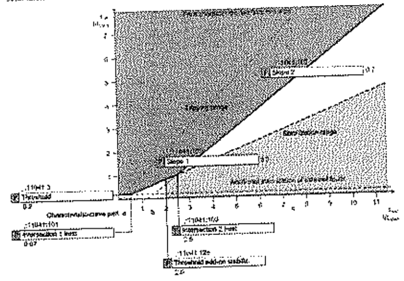

Figure 6-88 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0.7 does not reach the pickup characteristic, the pickup drops out.

Detection of External Faults

To detect external faults with transformer saturation in a reliable way, the measured curve is evaluated in the Diff.-Rest level by means of a detector. An external fault can occur if the motor feeds back to an external short circuit or if the motor starts up. The detector has 2 essential tasks:

- Blocking in the case of a definite high-current external fault
  The differential current and the restraint current are monitored on a phase basis in the Diff-Rest level immediately after fault inception. To ensure the stability of the saturation detection for low saturation free times of the primary current transformer, estimated values based on the difference quotients of the instantaneous values are used.
  If the estimated restraint current exceeds the Threshold add-on stabiliz. parameter and the expected value of the differential current of all phases is in the additional stabilization range (parameter Slope 1) (Figure 6-88) at the same time, the detector is active and the indication Blocked by ext. fault phsx appears. The tripping of the differential protection function is blocked.
  If an external fault arises and is cleared by the protection responsible for it, the additional stabilization drops out, if the dropout ratio (0.7) of the RMS value of the restraint current does not reach the Threshold add-on stabiliz. parameter (Figure 6-88), the additional stabilization drops out. The indication Blocked by ext. fault phsx is reset.
  If the differential current exceeds Slope 1 as a result of transformer saturation, that is, there is a pickup here, the blocking is limited in time (parameter Time of add-on stabiliz.).
  Starting with the indication Blocked by ext. fault phsx, the other phases can be blocked with the Crossblk. time add-on st. parameter. If differential currents due to transformer saturation spread to the other phases through the vector-group correction or residual current elimination, this blocking is necessary.
- Removal of the blocking with a change in fault location from external to internal
  An internal fault can arise as a consequence of an external fault. This fault change must be recognized and the blocking must be removed. The critical case is a short-circuit with current-transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation, the instantaneous values fall below an internal threshold in the saturation free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with cross block. The blocking of the tripping is removed and the indication Blocked by ext. fault phsx is reset.

DC-Component Detection

Low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization area is not attained, however.

To avoid an overfunction, the following steps are taken:

- The restraint current $I_{rest,phsx}$ is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) $I_{rest,phsx}$. The result is $I_{DC,phsx}$. This current is compared to the restraint current $I_{rest,phsx}$ and is checked for exceeding of the internal threshold.
- The differential current $I_{diff,phsx}$ must lie below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter Factor increasing char. with a default setting of 2.0. Here, only the threshold value and the gradient 1 are raised (see Figure 6-89). The indication Increase of char. (DC) is output. If the product of parameter Factor increasing char. and Slope 1 exceeds 0.85, the maximum increase of the raised Slope 1 is limited to 0.85.
- As additional criterion, the pickup indication Pickup (internal fault is present) or the indication of the additional stabilization Blocked by ext. fault phsx (high-current external fault) is sampled. If one of the 2 conditions is present, the characteristic-curve increase is stopped. A renewed pickup no longer resets the characteristic-curve increase. A pickup with DC-component detection occurs only if the raised operate curve is exceeded.

If the DC component $I_{DC,phsx}$ falls below the internal dropout threshold, the dropout delay is determined as follows:

It is assumed that the DC and remagnetization of the transformer last equally long. The magnetization is at the highest at the point in time in which the internal dropout threshold is attained. The time is measured from the start of the DC component detection until the internal dropout threshold is reached. Added to this time are 5 periods and from this, the dropout delay is derived. Following this, the characteristic-curve increase is reset to the original value. Figure 6-90 shows the overall logic.

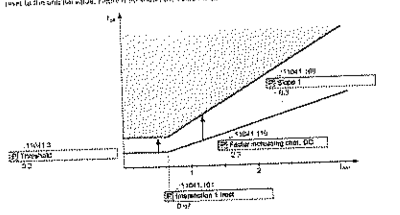

Figure 6-89 Increasing the Characteristic Curve after DC Detection

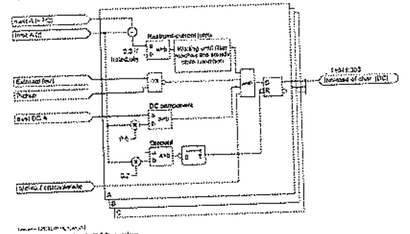

Figure 6-90 Logic DC Detection

Startup Detection

The pickup-value increase is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetization and being supplied with current at different operating points of their

hysteresis. These differential currents are low in fact, but they can lead to overfunction with sensitive setting of the differential protection.

With generators, the motor startup can also lead to higher currents. With the startup detection, you can make the protection somewhat less sensitive for a specific period of time and avoid overfunction. As a result, you achieve a comparable effect to that of DC-component recognition.

You can use the pickup-value increase at startup as an additional security against overfunction when switching in a previously currentless protected object. If the restraint current falls below a settable value Thresh. startup detection, in all phases, the pickup-value increase is activated. The pickup value Threshold and Slope 1 are raised by the set value in accordance with parameter Factor increasing char. As a rule here, Slope 1 cannot exceed a value of 0.85.

If the parameter Thresh. startup detection is exceeded, dropout occurs and a timing element (parameter Max. perm. Start. time) is started. Once this time has elapsed, the characteristic curve that was raised in all phases is reset to its original value. Figure 6-91 shows the logic diagram of the pickup recognition and Figure 6-92 the increased characteristic curve.

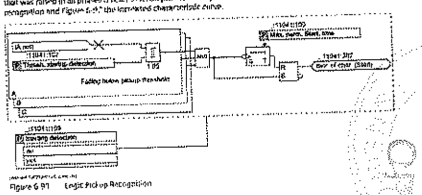

Figure 6-91 Logic Pickup Recognition

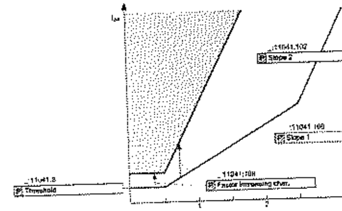

Figure 6-92 Characteristic-Curve Increase at Startup

Trip Logic of the Differential Protection Function Idiff

Figure 6-93 shows the trip logic. If the characteristic curve is exceeded (see Figure 6-88) a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following variables:

- Recognition of external faults that can simulate an internal fault through transformer saturation

In addition, in case of blocking due to an external error, a Cross block mechanism comes into effect

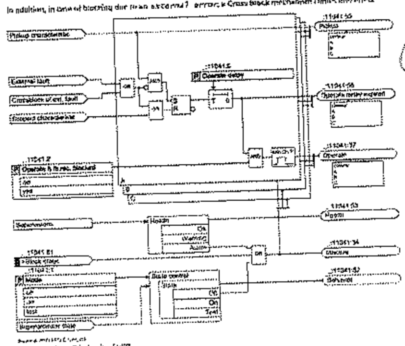

Figure 6-93 Trip Logic of Idiff

Differential Protection Function (Idiff Fast)

As a supplement to the differential protection function (Idiff), the Idiff fast function is available. The main task consists in switching off high-current internal faults in the shortest amount of time. The method controls current transformer saturation and is stable in the event of external transverse faults (integration in breaker-and-a-half arrangements).

Methodologically, 2 methods are combined:

- Instantaneous value method
- Filter-based method

Instantaneous Value Method

Through the instantaneous value method, an immediate evaluation of the sampled values of the differential (i_{diff}) and restraint current (i_{rest}) occurs. The absolute value adapted and vector group adapted currents (i*) are also the basis. The currents are defined positively to the node. The restraint current is the maximum current of all measuring points.

$$i_{diff,phsx}(t) = \left| \sum_{m=1}^{N} i^*_{phsx,m}(t) \right|$$

$$i_{rest,phsx}(t) = \underset{m=1}{\overset{N}{MAX}} \left| i^*_{phsx,m}(t) \right|$$

with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points

The evaluation of the restraint current is used to recognize saturated, high-current external faults. Figure 6-94 shows the operate curve. The parameter Threshold is set here such that it lies over the maximum fault current flowing. The gradient of the characteristic curve is fixed at 0.8.

In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current $di_{rest}(t)/dt$ is determined continuously and compared with an internal threshold.
- Condition 2: After that, a comparison determines whether the differential current is larger than the restraint current (characteristic curve Gradient in Figure 6-94): $i_{diff}(t) > 0.8 \cdot i_{rest}(t)$.
- Condition 3: After that, a comparison determines whether the differential current exceeds the parameter Threshold.

When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the function is blocked for 300 ms.

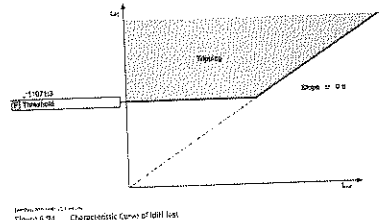

Figure 6-94 Characteristic Curve of Idiff fast

The 2 following figures show the behavior during an internal and an external fault. It is typical for the internal fault (Figure 6-95) that the differential current rises more quickly than the restraint current. After a few sampled values, the trip signal is issued. In case of an external fault, a differential current arises only after transformer saturation occurs. You can always assume, however, that the current is transferred a few milliseconds after occurrence of the fault. In accordance with Figure 6-97, the restraint current is larger than the differential current after occurrence of the fault, but condition 2 is not met and the function is therefore blocked.

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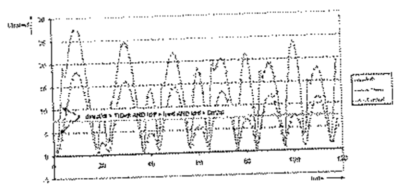

Figure 6-95 Curve Plot for Internal Fault with Transformer Saturation (k = 0.65)

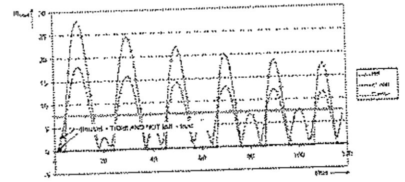

Figure 6-96 Curve Plot for External Fault with Transformer Saturation (k = 0.65)

Fundamental Component Method

Parallel to the instantaneous-value method, the fundamental-component method works with a temporal delay. Here, the same measured values are processed as with the Idiff method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) I_{rest} are entered in the operate curve according to Figure 6-94 and the trip decision is made.

Figure 6-97 shows the overall logic.

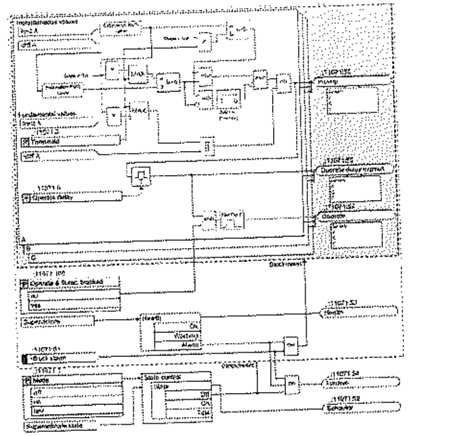

Figure 6-97 Logic of the Differential Protection Function Idiff Fast

Trip Logic of the Differential Protection

A common trip signal is formed from both subfunctions Idiff and Idiff fast. Figure 6-98 shows the respective logic.

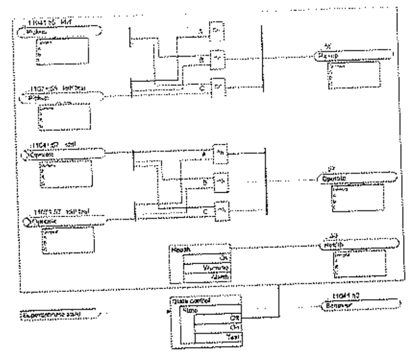

Figure 6-98 Overall Trip Logic

Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Storing of the fault record depends on the setting (see 3.4.2 Function Description). Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with external errors, along with the exceedance of the characteristic curve, a fault record is opened in case of a blocking by an external error or in case of a characteristic-curve increase through component recognition. This has the advantage that you can evaluate the transformer transfer method of the current transformers very well in case of a fault.

6.5.4 Application and Setting Notes

Setting information for the required setting parameters is provided for a typical motor protection application. Figure 6-99 shows a typical motor protection application. For motors with a power of more than 2 MW to 2 MW, Siemens recommends the use of differential protection. This prevents damage in the event of tripping in case of a short circuit. The application assumes that a current transformer is available at the motor neutral point. The motor differential protection is operational in the devices 7UT82, 7UT85, 7UT86, and 7UT87.

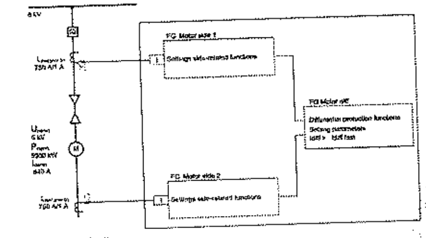

Figure 6-99 Connection Example

In the example, a 7UT85 is selected. 2 measuring inputs are interconnected on the 3-phase measuring points of side 1 and side 2. The measuring points must be interconnected with the corresponding function groups. Figure 6-100 shows the corresponding screenshot from DIGSI 5.

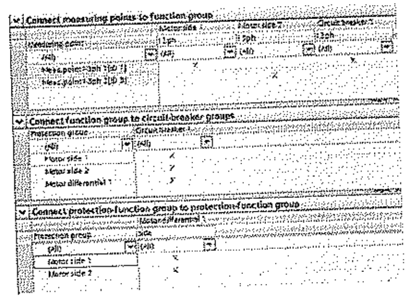

Figure 6-100 Internal Interconnections in DIGSI 5

Motor Side Function Group

In the Motor Side function group, make the following settings:

> **NOTE**
>
> Ensure that the correct transformer data are set at the measuring points.

Parameter: Rated apparent power

- Default setting (_:11671:103) Rated apparent power = 6.45 MVA

Set the Rated apparent power for the motor. For a motor with 2 sides, the setting is the same for both sides.

Parameter: Motor rated voltage

- Default setting (_:11671:102) Motor rated voltage = 6 kV

Set the Motor rated voltage for the motor. This is 6 kV in this example.

Motor Diff. Function Group

Make the following settings in the Motor Diff. function group for the Idiff functions.

Parameter: Threshold (Setting of the Characteristic Curve Parameters)

- Default setting (_:11041:3) Threshold = 0.2 I/Irated,obj

You set the pickup threshold for the differential current with this parameter. This is the total current flowing into the protection range during a short circuit, regardless of how it is distributed on the sides of the protected object. The pickup value is relative to the rated current of the protected object. The default setting at 0.2 I/Irated,obj is a practical value between sensitivity and possible disturbing influences.

Parameter: Intersection 1 Irest

- Default setting (_:11041:101) Intersection 1 Irest = 0.67 I/Irated,obj

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission errors of the current transformer even with small currents, half of the rated current is an appropriate setting value.

Parameter: Slope 1

- Default setting (_:11041:100) Slope 1 = 0.3

With the Slope 1, you avoid an overfunction of the differential protection with low-current external faults as a consequence of current-transformer transmission errors (stationary and dynamic faults). The default setting of 0.3 is sufficient for many applications.

> **NOTE**
>
> The stabilization method has been changed from that in SIPROTEC 4 (7UT6x, 7UM62). For this reason, select a higher gradient (also see 6.5.3 Function Description).

Parameter: Intersection 2 Irest

- Default setting (_:11041:103) Intersection 2 Irest = 2.5 I/Irated,obj

> **NOTE**
>
> Expect transmission problems with current transformers with larger currents flowing through: Slope 2 must be selected to be larger.

The parameter Intersection 2 Irest determines from which restraint current the Slope 2 begins. The default setting 2.5 I/Irated,obj is a practical value.

Parameter: Slope 2

- Default setting (_:11041:102) Slope 2 = 0.7

With the parameter Slope 2, an overfunction of the differential protection is avoided with high-current external faults as a consequence of current-transformer transmission errors (for example, due to saturation). A value greater than or equal to double the value of Slope 1 is practical. As the default setting, 0.7 was selected.

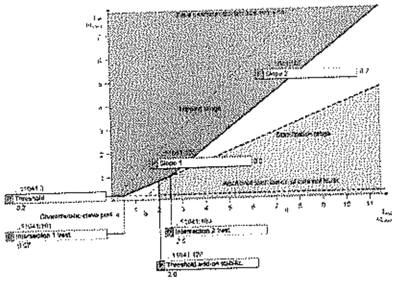

Figure 5-101 Characteristic Curve with the Default Settings

Parameter: Starting detection

- Default setting (_:11041:106) Starting detection = yes

To avoid overfunction due to the motor starting current, Siemens recommends activating startup surge detection for motor protection applications. This is also recommended for protecting common mode reactors. In this case, set the default setting Starting detection = yes.

Parameter: Thresh. startup detection

- Default setting (_:11041:107) Thresh. startup detection = 0.1 I/Irated,obj

If the restraint current falls below this threshold value, the subsequently set characteristic curve increase becomes effective with activated function. The default setting value of 0.1 I/Irated,obj is recommended for the application.

Parameter: Factor increasing char.

- Default setting (_:11041:108) Factor increasing char. = 2.0

Change the default setting value in the case of application. An increase to the value 2.0 has proven itself to be sufficient for many applications.

Parameter: Max. perm. Start. time

- Default setting (_:11041:109) Max. perm. Start. time = 5.0 s

The setting value must be above the maximum permissible starting time of the connected motor. Refer to the motor data sheet for the starting time (for example, Locked Rotor time). To guarantee tripping through the motor protection (starting time monitoring) and avoid overfunction, select a somewhat longer time (factor

1.2 or higher). For the motor in the example, a rotor locked for 6.5 s is assumed for rated voltage. The setting value should be larger than 1.2 · 6.5 s = 7.8 s. Siemens recommends a setting of 10 s.

Parameter: Factor increasing char. DC (DC-Component Recognition)

- Default setting (_:11041:110) Factor increasing char. DC = 2.0

DC component recognition is always active. As a result of the DC components, transmission problems can arise (for example, phase angle rotations) in current transformers with small currents flowing. For this reason, the Threshold and the Slope 1 are raised by the set factor. The default setting of 2.0 has proven itself with numerous applications.

Recognition of External Faults

In Figure 5-101, the range Additional Stabilization with External Fault is represented. The range is described by the Additional stabilization threshold value and Slope 1 parameters. With an external short circuit, the differential currents can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: Threshold add-on stabiliz.

- Default setting (_:11041:128) Threshold add-on stabiliz = 2.0

The Threshold add-on stabiliz. parameter allows you to set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of 2 is practical. The additional stabilization range is limited by the parameters Threshold add-on stabiliz. and Slope 1.

Parameter: Time of add-on stabiliz.

- Default setting (_:11041:129) Time of add-on stabiliz. = 0.3 s

As orientation for the setting value, you can use the operate time of the external feeder protection. Additionally, take into account the opening time of the circuit breaker. Thus, the following calculation rule results:

$t_{set} = t_{Ope.protection} + t_{circuit\,breaker}$

The default setting is a practical value. You must adapt the value appropriately to use. The value 0 deactivates the recognition of external errors.

Parameter: Crossblk. time add-on st.

- Default setting (_:11041:130) Crossblk. time add-on st. = 0.3 s

The additional stabilization acts separately on each phase. However, it can be extended to block all phases. Siemens recommends the activation of the cross-block function by means of a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Protection Stage IDIFF Fast

The task of this protection stage is the fast capture of high current internal faults (see also 6.5.2 Function Description). For this reason, the protection stage must always be activated.

Parameter: Threshold

- Default setting (_:11041:3) Threshold = 6 I/Irated,obj

Siemens recommends setting the threshold value greater than or equal to the starting current. For example, if the starting current of the motor is 5.6 $I_{rated,motor}$, set the threshold to 6 $I_{rated,motor}$.

6.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:100	General:Protection Mode		• Transformer • Current node	Transformer
_:2311:101	General:Meas. gnd. current side 1		• no • yes	no
_:2311:102	General:Meas. gnd. current side 2		• no • yes	no
_:2311:103	General:Meas. gnd. current side 3		• no • yes	no
_:2311:181	General:Meas. gnd. curr. autotrsf.		• no • with CT 1ph • with CT 3ph	no
_:2311:182	General:Meas. gnd. curr. comp. side		• no • yes	no
_:2311:105	General:CT mismatch side 1 M3ph 1		0.000 to 100.000	0.000
_:2311:106	General:CT mismatch side 1 M3ph 2		0.000 to 100.000	0.000
_:2311:107	General:CT mismatch side 1 M3ph 3		0.000 to 100.000	0.000
_:2311:108	General:CT mismatch side 1 M3ph 4		0.000 to 100.000	0.000
_:2311:109	General:CT mismatch side 1 M1ph		0.000 to 100.000	0.000
_:2311:110	General:CT mismatch side 2 M3ph 1		0.000 to 100.000	0.000
_:2311:111	General:CT mismatch side 2 M3ph 2		0.000 to 100.000	0.000
_:2311:112	General:CT mismatch side 2 M3ph 3		0.000 to 100.000	0.000
_:2311:113	General:CT mismatch side 2 M3ph 4		0.000 to 100.000	0.000
_:2311:114	General:CT mismatch side 2 M1ph		0.000 to 100.000	0.000
_:2311:115	General:CT mismatch side 3 M3ph 1		0.000 to 100.000	0.000
_:2311:116	General:CT mismatch side 3 M3ph 2		0.000 to 100.000	0.000
_:2311:117	General:CT mismatch side 3 M3ph 3		0.000 to 100.000	0.000
_:2311:118	General:CT mismatch side 3 M3ph 4		0.000 to 100.000	0.000
_:2311:119	General:CT mismatch side 3 M1ph		0.000 to 100.000	0.000
_:2311:183	General:CT mismatch M1ph		0.000 to 100.000	0.000
_:2311:130	General:CT mismatch S1 M3ph 1 N		0.000 to 100.000	0.000
_:2311:131	General:CT mismatch S1 M3ph 2 N		0.000 to 100.000	0.000

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:132	General:CT mismatch S1 M3ph 3 N		0.000 to 100.000	0.000
_:2311:133	General:CT mismatch S1 M3ph 4 N		0.000 to 100.000	0.000
_:2311:134	General:CT mismatch side 1 M1ph N		0.000 to 100.000	0.000
_:2311:176	General:CT mismatch S2 M3ph 1 N		0.000 to 100.000	0.000
_:2311:135	General:CT mismatch S2 M3ph 2 N		0.000 to 100.000	0.000
_:2311:136	General:CT mismatch S2 M3ph 3 N		0.000 to 100.000	0.000
_:2311:137	General:CT mismatch S2 M3ph 4 N		0.000 to 100.000	0.000
_:2311:177	General:CT mismatch side 2 M1ph N		0.000 to 100.000	0.000
_:2311:138	General:CT mismatch S3 M3ph 1 N		0.000 to 100.000	0.000
_:2311:139	General:CT mismatch S3 M3ph 2 N		0.000 to 100.000	0.000
_:2311:140	General:CT mismatch S3 M3ph 3 N		0.000 to 100.000	0.000
_:2311:141	General:CT mismatch S3 M3ph 4 N		0.000 to 100.000	0.000
_:2311:178	General:CT mismatch side 3 M1ph N		0.000 to 100.000	0.000
_:2311:184	General:CT mismatch M1ph N		0.000 to 100.000	0.000
_:2311:191	General:Reference side is		• not assigned • Side 1 • Side 2 • Side 3	not assigned
_:2311:151	General:MU-ID Side 1 Mp3ph 1		0 to 100	0
_:2311:152	General:MU-ID Side 1 Mp3ph 2		0 to 100	0
_:2311:153	General:MU-ID Side 1 Mp3ph 3		0 to 100	0
_:2311:154	General:MU-ID Side 1 Mp3ph 4		0 to 100	0
_:2311:155	General:MU-ID Side 1 Mp1ph		0 to 100	0
_:2311:156	General:MU-ID Side 2 Mp3ph 1		0 to 100	0
_:2311:157	General:MU-ID Side 2 Mp3ph 2		0 to 100	0
_:2311:158	General:MU-ID Side 2 Mp3ph 3		0 to 100	0
_:2311:159	General:MU-ID Side 2 Mp3ph 4		0 to 100	0
_:2311:160	General:MU-ID Side 2 Mp1ph		0 to 100	0

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:161	General:MU-ID Side 3 Mp3ph 1		0 to 100	0
_:2311:162	General:MU-ID Side 3 Mp3ph 2		0 to 100	0
_:2311:163	General:MU-ID Side 3 Mp3ph 3		0 to 100	0
_:2311:164	General:MU-ID Side 3 Mp3ph 4		0 to 100	0
_:2311:165	General:MU-ID Side 3 Mp1ph		0 to 100	0
_:2311:185	General:MU-ID Mp1ph		0 to 100	0
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	yes
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	2.0
_:11041:109	I-DIFF:Max. perm. Start time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s; ∞	0.30 s
_:11041:130	I-DIFF:Crossblk. time add-on st.		0.00 s to 2.00 s; ∞	0.30 s
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no

6.5.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I rest.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I rest. operate phA	MV	O
_:2311:315	General:I rest. operate phB	MV	O
_:2311:316	General:I rest. operate phC	MV	O
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Start. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:312	I-DIFF:Blocked by ext. fault	ACT	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:54	I-DIFF fast:Inactive	SPS	O
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:56	I-DIFF fast:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

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6.6 Generator Differential Protection

6.6.1 Overview of Functions

The Generator differential protection function (ANSI 87G):

- Detects short circuits in generators
- Detects ground faults in generators with a grounded neutral point (typical for low voltage)
- Is stable in the event of external short circuits with current-transformer saturation through intelligent saturation-detection methods
- Triggers safely in the case of internal high-current faults through an additional high-current stage

6.6.2 Structure of the Function

The Generator differential protection function is used in the Generator diff function group. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The Generator differential protection function consists of the tripping stages Idiff and Idiff fast. The tripping stages can be blocked. In addition you can switch the tripping stages on and off.

In the function groups Generator side and Generator stator:

- The side-related protection settings are performed
- The side-related calculations are performed
- All data (setting values, detected currents) are relayed to the Generator diff function group

The side-related protection functions can run in the Generator side function group, for example overload protection, overcurrent protection, etc.

The majority of the typical generator protection functions are located in the Generator stator function group. These work with the neutral-point side current transformers.

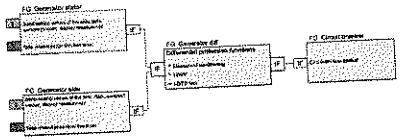

Figure 6-102 Embedding of the Function

6.6.3 Functional Description

Basic Principle of Differential Protection

Differential protection is based on a comparison of currents (Kirchhoff current law). When comparing the current, use is made of the fact that a protected object uses the same current I in a non faulty operating state on both sides (dotted in Figure 6-103). This current flows into the range being observed on one side and leaves it again on the other side. A current differential is a sure indication of a fault within the protected object. The

calculation of the difference is determined through the current-direction definition. The current direction is defined as positive to the protected object. The current difference results from the vector addition of the currents.

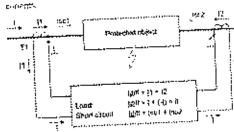

Figure 6-103 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in chapter Differential Protection Function (Idiff), Page 486.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers W1 and W2 (Figure 6-103), a corresponding differential current I_{diff} occurs. When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current (I_{rest}) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The definition for 2 measuring points is:

A trip or differential current is

$I_{diff} = |I_1 + I_2|$

as well as a restraint current of

$I_{rest} = Max (|I_1| ; |I_2|)$

For more than 2 measuring points, this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different feeding behavior for internal short circuits.

$I_{rest} = Max (|I_1| ; |I_2| ; ... |I_n|)$

To clarify the effect, 3 important operating states are observed with ideal and adapted measurands.

- Through fault current in healthy operation or externally caused error:
  I_1 flows into the protection range, I_2 flows out of the protection range, that is, negative compared with the prefix definition, thus $I_2 = -I_1$;
  in addition $|I_2| = |I_1|$
  $I_{diff} = |I_1 + I_2| = |I_1 - I_1| = 0$
  $I_{rest} = Max (|I_1| ; |I_2|) = |I_1| = |I_2|$
  No tripping quantity ($I_{diff} = 0$); the stabilization (I_{rest}) corresponds to the flowing current.
- Internal short circuit, feed from both sides with equal amount of currents, for example
  Then $I_2 = I_1$, in addition $|I_2| = |I_1|$
  $I_{diff} = |I_1 + I_2| = |I_1 + I_1| = 2 \cdot |I_1|$
  $I_{rest} = Max (|I_1| ; |I_2|) = |I_1| = |I_2|$
  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the restraining quantity (I_{rest}).

- Internal short circuit, feed only from one side:
  Then $I_2 = 0$
  $I_{diff} = |I_1 + I_2| = |I_1 + 0| = |I_1|$
  $I_{rest} = Max (|I_1| ; |I_2|) = |I_1|$
  The tripping quantity (I_{diff}) and the restraining quantity (I_{rest}) are of the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with Figure 6-104, there are 2 typical scenarios:

- High-current, external short circuit
  First, the current on both sides is transferred and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current I_{rest} drops. Once the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.
- Low-current, external short circuit
  Current transformers can also become saturated through the large direct current time constant (switching of transformers, motors), and small currents flowing through. This manifests itself as a phase-angle rotation of the current. Extending the characteristic curve in a prestabilized area is possible.

Intelligent saturation-detection methods capture this state and lead to a temporally limited blocking of the Differential protection function.

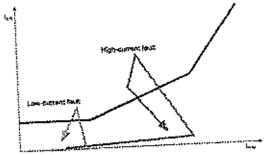

Figure 6-104 Principle Current Course in External Short Circuit and Temporary Current-Transformer Saturation on One Side

Logic of the Function

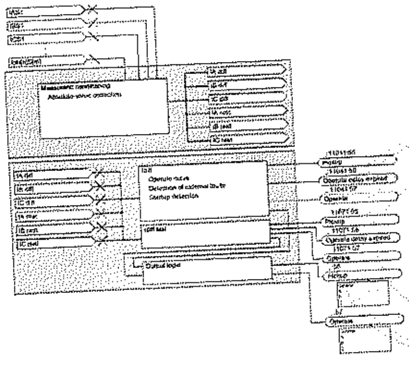

Figure 6-105 Logic Diagram of the Motor Differential Protection Function

In the following, the essential components of differential protection are described in detail.

Measurand Processing

Absolute-Value Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection function processes 20 sampled values per period. In addition, the sampled values stacked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 80 Hz).

The Idiff-fast stage works on non-frequency tracked values and thus, implements fast operate times with low frequencies.

The absolute value is adapted via the following formula:

$$i_{adap,x} = k \cdot i_{prim}$$

$$\text{with } k = \frac{I_{rated\,prim,CT}}{I_{rated\,obj,Ns}} = \frac{I_{rated\,prim,CT}}{\frac{S_{rated\,obj}}{V_{rated\,Si} \cdot \sqrt{3}}}$$

$i_{adap,x}$	Adapted instantaneous value per phase (x = A, B, C)
i_{prim}	Instantaneous value per phase (x = A, B, C)
k	Correction value per measuring point
$I_{rated\,prim,CT}$	Primary transformer rated current per measuring point
$I_{rated\,obj,Ns}$	Primary rated current of the protected object
$S_{rated\,obj}$	Reference power (maximum rated apparent power of the protected object)
$V_{rated\,Si}$	Rated voltage of the respective side (measuring point) of the protected object

Differential Protection Function (Idiff)

A differential current per phase based on the instantaneous value variables is calculated from the processed currents (see section Measurand Processing). The direction of current flow is defined as to the protected object as positive. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length: 1 period (20 sampled values)).

The currents of that measuring point whose RMS value is the largest are used as restraint current. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation, the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

$$i_{diff,phase} = \sum_{m=1}^{N} i_{adap,x,m} \rightarrow I_{diff,phase} = FIR(i_{diff,phase})$$

$$I_{phase,x,m} = \sqrt{\frac{1}{n}\sum_{k=1}^{n} i^2_{adap,x,m}(k)}$$

$$I_{rest,phase} = \underset{m=1}{\overset{N}{MAX}} I_{phase,x,m}$$

with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ... N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)
FIR	Fourier filter
MAX	Maximum-value determination

Pickup Characteristic

Figure 6-106 shows the pickup characteristic of the differential protection. The characteristic curve branch a represents the sensitivity threshold of the differential protection (parameter Threshold) and considers constant fault currents like magnetizing currents.

The characteristic branch b (parameter Intersection 1 Irest and Slope 1) considers current-proportional faults under normal operating conditions.

These faults can occur for the following reasons:

- Transformation errors of the current transformers and the input transformer of the device
- Adaptation deviations

The characteristic curve branch c (parameter Intersection 2 Irest and Slope 2) protects the differential protection against overfunction in case of high current external faults and transformer saturation. In this area, transformer saturation can arise due to high short-circuit currents, and because of this, a higher differential current results.

In order to avoid overfunction in the event of external faults with transformer saturation, a logic is implemented that uses the characteristic curve Additional stabilization of external faults. If the operating point is located in the additional stabilization area and exceeds the operate curve from there, then the logic becomes active and blocks the differential protection.

The additional stabilization range is derived from the Threshold add-on stabiliz. and Slope 1 parameters.

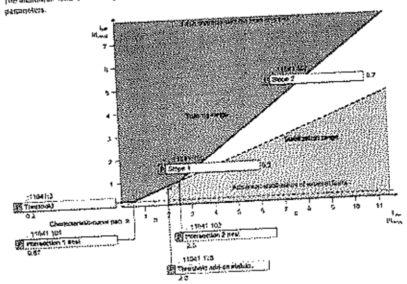

Figure 6-106 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0.7 does not reach the pickup characteristic, the pickup drops out.

Detection of External Faults

To detect external faults with transformer saturation in a reliable way, the characteristic curve is evaluated in the Diff. Prot level by means of a detector. An external fault can occur if the motor feeds back to an external short circuit and the motor starts up. The detector has 2 essential tasks:

- **Blocking in the case of a definite high-current external fault**

  The differential currents and the restraint currents are monitored on a phase basis ... to ensure the stability of the saturation detection for low saturation ... after fault inception ... estimated values based on the difference quotients of the instantaneous values are used.

  If the estimated restraint current ... the Threshold add-on stabiliz. parameter and the ... value of the differential current of all phases is in the additional stabilization range (parameter Slope 1) (Figure 6-99) at the same time, the Detector is active and the indication Blocked by ext. fault phsx appears. The tripping of the differential protection function is blocked.

  If an internal fault arises ... the additional stabilization drops out ... Threshold add-on stabiliz. ... The indication Blocked by ext. fault phsx is reset.

  If the differential current exceeds Slope 1 as a result of transformer saturation, that is, there is a pickup phase, the blocking is limited in time (parameter: Time of add-on stabiliz.).

  Starting with the indication Blocked by ext. fault phsx, the other phases can be blocked with the Cross-blk. time add-on st. parameter. If differential currents due to transformer saturation spread to the other phases through the vector group correction or residual current elimination, this blocking is necessary.

- **Removal of the blocking with a change in fault location from external to internal**

  An internal fault can arise as a consequence of an external fault. This fault change must be recognized and the blocking must be removed. The critical case is a short-circuit with current-transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation, the instantaneous values fall below an internal threshold in the saturation free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with cross block ... The blocking of the tripping is removed and the indication Blocked by ext. fault phsx is reset.

DC Component Detection

Low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization area is not attained, however.

To avoid an overfunction, the following steps are taken:

- The restraint current $I_{rest,pow}$ is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) ... This current is compared to the restraint current ... and is checked for exceeding of the internal threshold.
- The differential current $I_{diff,pow}$ must be below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter Factor increasing char. with a default setting of 2.5. Here, only the threshold value and the gradient 1 are raised (see Figure 6-107). The indication Increase of char. (DC) is output. If the product of parameter Factor increasing char. and Slope 1 exceeds 0.85, the maximum increase of the raised Slope 1 is limited to 0.85.
- As additional criterion, the pickup indication Pickup (internal fault is present) or the indication of the additional stabilization Blocked by ext. fault phsx (high-current external fault) is sampled. If one of the 2 conditions is present, the characteristic-curve increase is stopped. ... A pickup with DC-component detection occurs only if the raised operate curve is exceeded.

If the DC component ... falls below the internal dropout threshold, the dropout delay is determined as follows.

It is assumed that the DC component ... of the transformer ... equally large. The ... time is measured from the highest at the point in time at which the internal dropout threshold is attained. ... Following this, the characteristic-curve increase is reset to the initial value. Figure 6-108 shows the overall logic.

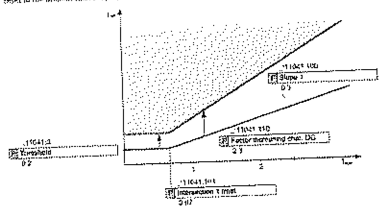

Figure 6-107 Increasing the Characteristic Curve after DC Detection

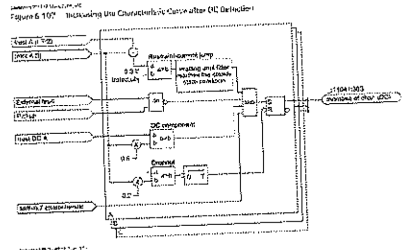

Figure 6-108 Logic DC Detection

Startup Detection

The pickup value increase is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetizations and being supplied with current at different operating points of their ...

... these differential currents are low in fact, but they can lead to overfunction with sensitive setting of the differential protection.

With generators, the motor startup can also lead to higher currents. With the startup detection, you can make the protection less sensitive for a specific period of time and avoid overfunction. As a result, you achieve a comparable effect to that of DC component recognition.

You can use the pickup-value increase at startup as an additional security against overfunction when switching ... If the restraint current falls below a settable value Thresh. startup detection in all phases, the pickup-value increase is activated. The pickup value Threshold and Slope 1 are raised by the set value in accordance with parameter Factor increasing char. ... Slope 1 cannot exceed a value of 0.85.

If the parameter Thresh. startup detection is exceeded, dropout occurs and a timing element (parameter Max. perm. Start. time) is started. Once this time has elapsed, the characteristic curve that was raised in all phases is reset to its original value. Figure 6-109 shows the logic diagram of the pickup recognition and Figure 6-110 the elevated characteristic curve.

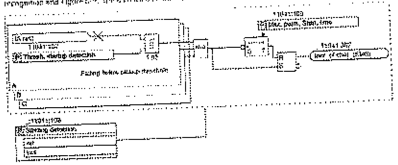

Figure 6-109 Logic Pickup Recognition

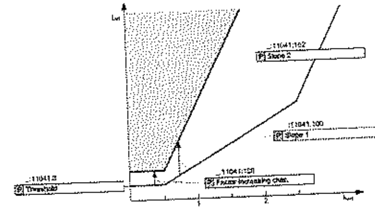

Figure 6-110 Characteristic-Curve Increase at Startup

Trip Logic of the Differential Protection Function Idiff

Figure 6-91 shows the trip logic. If the characteristic curve is exceeded (see Figure 6-88) a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following variables:

- Recognition of external faults that can simulate an internal fault through transformer saturation

In addition, in case of blocking due to an external error, a Cross block mechanism comes into effect.

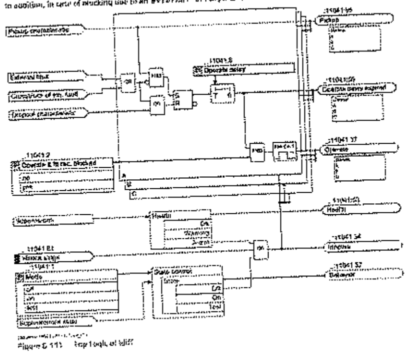

Figure 6-111 Trip Logic of Idiff

Differential Protection Function (Idiff fast)

As a supplement to the differential protection function (Idiff), the Idiff fast function is available. The main task consists in switching off high-current internal faults in the shortest amount of time. The method ... is stable in the event of external transverse faults ...

2 methods are combined:

- Instantaneous value method
- Filter based method

Instantaneous-Value Method

Through the instantaneous-values method, an immediate evaluation of the sampled values of the differential ... and restraint current ... The absolute value ... are also the basis. ... The restraint current is the maximum ... current of all measuring points.

$$i_{diff,phsx}(t) = \left|\sum_{m=1}^{N} i_{phsx,m}(t)\right|$$

$$i_{rest,phsx}(t) = \underset{m=1}{\overset{N}{MAX}} |i_{phsx,m}(t)|$$

with

x Variable (1, 2, 3) for the phase currents (A, B, C)
m Variable (1, 2, ..., N) for the measuring points
N Number of measuring points

The evaluation of the restraint current is used to recognize saturated, high current external faults.

Figure 6-94 shows the operate curve. The parameter Threshold is set here such that it lies over the maximum fault current limiting. The gradient of the characteristic curve is fixed at 0.8.

In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current di_{rest}/dt is determined continuously and compared with an internal threshold.
- Condition 2: After that, a comparison determines whether the differential current is larger than the restraint current (characteristic curve Gradient in Figure 6-94): $i_{diff}(t) > 0.8 \cdot i_{rest}(t)$.
- Condition 3: After that, a comparison determines whether the differential current exceeds the parameter Threshold.

When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the function is blocked for 300 ms.

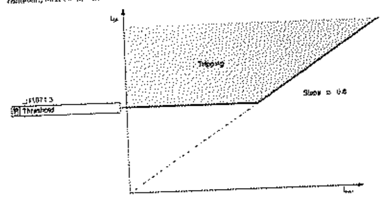

Figure 6-112 Characteristic Curve of Idiff fast

The 2 following figures show the behavior during an internal and an external fault. It is typical for the internal fault (Figure 6-113) that the differential current rises more quickly than the restraint current. After a few sampled values, the trip signal is issued. In case of an external fault, a differential current arises only after transformer saturation occurs. ... the current is transferred a few milliseconds after occurrence of the fault. In accordance with Figure 6-114, the restraint current is larger than the differential current after occurrence of the fault, but condition 2 is not met and the function is therefore blocked.

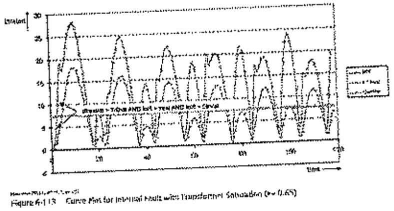

Figure 6-113 Curve Plot for Internal Fault with Transformer Saturation (k = 0.65)

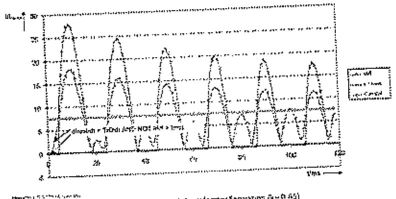

Figure 6-114 Curve Plot for External Fault with Transformer Saturation (k = 0.65)

Fundamental-Component Method

Parallel to the instantaneous-value method, the fundamental component-method works with a temporal delay. Here, the same measured values are processed as with the Idiff method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) I_{rest} are ... in the operate curve according to Figure 6-94 and the trip decision is made.

Figure 6-95 shows the overall logic.

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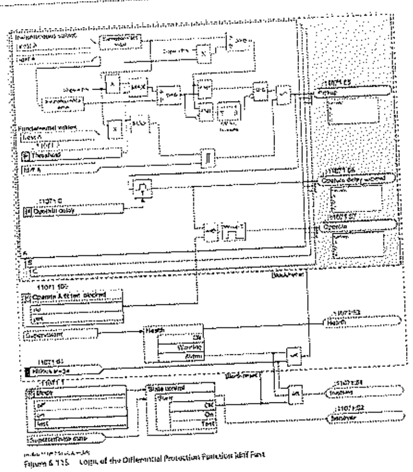

Figure 6-115 Logic of the Differential Protection Function Idiff Fast

Trip Logic of the Differential Protection

A common trip signal is formed from both subfunctions Idiff and Idiff fast. Figure 6-116 shows the respective logic.

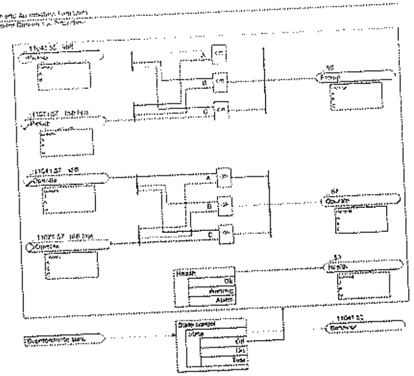

Figure 6-116 Overall Trip Logic

Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with external errors, along with the exceedance of the characteristic curve, a fault record is opened in case of a blocking by an external error or in case of a characteristic-curve increase through component recognition. This has the advantage that you can evaluate the transformer transfer method of the current transformers very well in case of a fault.

6.6.4 Application and Setting Notes

This chapter provides setting information for the required setting parameters for a typical generator protection application. Figure 6-117 shows a typical generator protection application. This prevents significant damage to the generator in the event of tripping in case of a short circuit. Therefore, the Generator differential protection also makes sense for less powerful generators (< 5 MVA).

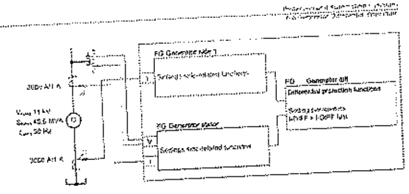

Figure 6-117 Connection Example

The connection example refers to an application in the 7UT85. The 3-phase current measuring points are connected to the function groups Generator side 1 and Generator stator. The differential protection function runs in the Generator diff function group.

The following screen shot from DIGSI 5 shows the connection of the measuring points as well as the connection of the function groups.

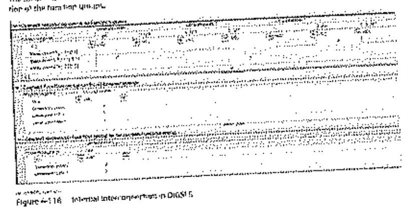

Figure 6-118 Internal Interconnections in DIGSI 5

Generator Side and Generator Stator Function Groups

Make the following settings in the function groups Generator side and Generator stator. They are needed for scaling the currents and processing the differential protection.

> **NOTE**
> Ensure that the correct transformer data are set at the measuring points.
> The data in the example are for the following current transformers: 3 000 A/1 A

Parameter: Rated apparent power

- Default setting (_:14671:103) Rated apparent power = 46.60 MVA

Set the Rated apparent power of the generator. With one generator, the setting value for both function groups (sides) is the same.

Parameter: Rated voltage

- Default setting (_:14671:102) Rated voltage = 11 kV

Set the Rated voltage of the generator. The rated voltage is 11 kV in this example. The setting is the same for both function groups.

Generator Diff Function Group

Make the following settings in the Generator diff function group for the Idiff function:

Parameter: Threshold (Setting the characteristic-curve parameters)

- Default setting (_:11041:3) Threshold = 0.2 I/Irated,obj

You set the pickup threshold for the differential current with this parameter. This is the total current flowing into the protection range during a short circuit, regardless of how it is distributed on the sides of the protected object. The pickup value refers to the rated current of the protected object. The default setting of 0.2 I/Irated,obj is a practical value between sensitivity and possible disturbing influence.

Parameter: Intersection 1 Irest

- Default setting (_:11041:101) Intersection 1 Irest = 0.67 I/Irated,obj

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission errors of the current transformer even with small currents, half of the rated current is an appropriate setting value.

Parameter: Slope 1

- Default setting (_:11041:100) Slope 1 = 0.3

With the Slope 1 parameter, you avoid an overfunction of the differential protection with low current external faults as a consequence of current-transformer transmission errors (stationary and dynamic faults). The default setting of 0.3 is sufficient for many applications.

> **NOTE**
> The stabilization method has been changed from that in SIPROTEC 4 (7UT6x, 7UM62). For this reason, select a higher slope (also see 6.6.3 Functional Description).

Parameter: Intersection 2 Irest

- Default setting (_:11041:103) Intersection 2 Irest = 2.5 I/Irated,obj

With the Intersection 2 Irest parameter, you determine from which restraint current the Slope 2 begins. The default setting 2.5 I/Irated,obj is a practical value.

Parameter: Slope 2

- Default setting (_:11041:102) Slope 2 = 0.7

With the Slope 2 parameter, an overfunction of the differential protection is avoided with high current external faults as a consequence of current-transformer transmission errors (for example, due to saturation). A value greater than or equal to double the value of Slope 1 is practical. As the default setting, 0.7 was selected.

> **NOTE**
> If excessive current flows are cause to expect transmission problems for the current transformers, set the Slope 2 to a higher value.

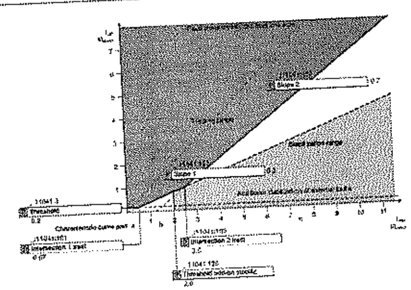

Figure 6-119 Characteristic Curve with the Default Settings

Parameter: Starting detection

- Default setting (_:11041:106) Starting detection = no

If the generator works into busbars to which motors are also connected, Siemens recommends activating the startup detection for generator protection applications, since the motor starting currents can influence the transmission behavior of the current transformers. In this case, set the parameter Starting detection to yes.

Parameter: Thresh. startup detection

- Default setting (_:11041:107) Thresh. startup detection = 0.1 I/Irated,obj

If the restraint current falls below this threshold value, the subsequently set characteristic curve increase becomes effective with activated function. Increase the default setting of 0.1 I/Irated,obj for generator protection applications corresponding to your operating conditions. Adjust the parameter Thresh. startup detection to the lower load limit (possible order of magnitude, for example, 0.4 I/Irated,obj).

Parameter: Factor increasing char.

- Default setting (_:11041:108) Factor increasing char. = 1.0

Change the default setting value in the case of application. An increase to the value 2.0 has proven itself to be sufficient for many applications.

Parameter: Max. perm. Start. time

- Default setting (_:11041:109) Max. perm. Start. time = 5.0 s

The setting value must lie above the maximum permissible starting time of the connected motor. Refer to the motor data sheets for the starting time (for example, Locked Rotor time). To ensure tripping through the

motor protection (starting-time supervision) and avoid overfunctions, select a slightly longer time (factor 1.2 or higher). For the motor in the example, a starting time of 6.5 s was assumed at 90 % rated voltage and rated torque. The setting value should be larger than 1.2 · 6.5 s = 7.8 s. Siemens recommends a setting value of 10 s.

Parameter: Factor increasing char. DC (DC-component detection)

- Default setting (_:11041:110) Factor increasing char. DC = 2.0

DC-component detection is always active. As a result of the DC components, transmission problems can arise (for example, phase angle rotations) in current transformers with small currents flowing. For this reason, the Threshold and the Slope 1 are increased by the set factor. The default setting of 2.0 has proven itself with numerous applications.

Recognition of External Faults

In Figure 6-119, the range Additional stabilization with external faults is represented. The range is described by the Threshold add-on stabiliz. and Slope 1 parameters. With an external short circuit, the differential current can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: Threshold add-on stabiliz.

- Default setting (_:11041:128) Threshold add-on stabiliz. = 2.0

With the Threshold add-on stabiliz. parameter, you can set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of 2 is practical. The additional stabilization range is limited by the parameters Threshold add-on stabiliz. and Slope 1.

Parameter: Time of add-on stabiliz.

- Default setting (_:11041:129) Time of add-on stabiliz. = 0.3 s

As orientation for the setting value, you can use the operate time of the external backup protection. Additionally, take into account the opening time of the circuit breaker. Thus, the following calculation rule results:

$T_{Stab} = T_{backup\ protection} + T_{open\ circ.\ breaker}$

The default value is a practical value. You must adapt the value appropriately in use. The value 0 deactivates the detection of external faults.

Parameter: Crossb. time add-on st.

- Default setting (_:11041:130) Crossb. time add-on st. = 0.3 s

The additional stabilization acts separately on each phase. However, it can be extended to block all phases. Siemens recommends the activation of the crossblock function with a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Protection stage Idiff fast

The task of this protection stage is the fast detection of high-current internal faults (see also 6.6.3 Functional Description). For this reason, the protection stage must always be activated.

Parameter: Threshold

- Default setting (_:11041:3) Threshold = 6 I/Irated,obj

If there are internal faults in the generator with simultaneous network operation, you can assume a current feed from both the generator and the network side. If there is an external error, current is only fed from the generator. The saturation and then directional transient starting takes effect at fault inception. If you assume that the transformers are nearly identical and do not saturate immediately, you can use the machine short data and reactances to estimate the maximum fault current. The current transformer design is based on this fault current.

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With the assumption described (not immediately saturated), you set the value via the transient short-circuit current.

I-DIFF fast > 1.1/xd' · I_tran,sec,max

Values for xd' from 0.15 to 0.35 result in setting values from approx. 3 I_rated,obj to 7 I_rated,obj.

Example:

Direct-axis transient reactance xd' (calculated) = 0.19

This results in a transient current of 1.1/0.19 · I_rated,gen = 5.74 I_rated,generator = 5.74 I_rated,obj.

For the parameter I_(_:11071:3) Threshold, you can use the default setting of 7.5 I/I_rated,obj.

6.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:100	General:Meas. gnd. current side 1		• no • yes	no
_:2311:101	General:Meas. gnd. current side 2		• no • yes	no
_:2311:102	General:Meas. gnd. current side 3		• no • yes	no
_:2311:103	General:Meas. gnd. current side 4		• no • yes	no
_:2311:104	General:Meas. gnd. current side 5		• no • yes	no
_:2311:151	General:Meas. gnd. curr. mI-sides		• no • with CT 1ph • with CT 3ph	no
_:2311:182	General:Meas. gnd. curr. comp.side		• no • yes	no
_:2311:105	General:CT mismatch side 1 M3ph 1		0.000 to 100.000	0.000
_:2311:106	General:CT mismatch side 1 M3ph 2		0.000 to 100.000	0.000
_:2311:107	General:CT mismatch side 1 M3ph 3		0.000 to 100.000	0.000
_:2311:108	General:CT mismatch side 1 M3ph 4		0.000 to 100.000	0.000
_:2311:109	General:CT mismatch side 1 M1ph		0.000 to 100.000	0.000
_:2311:110	General:CT mismatch side 2 M3ph 1		0.000 to 100.000	0.000
_:2311:111	General:CT mismatch side 2 M3ph 2		0.000 to 100.000	0.000
_:2311:112	General:CT mismatch side 2 M3ph 3		0.000 to 100.000	0.000
_:2311:113	General:CT mismatch side 2 M3ph 4		0.000 to 100.000	0.000
_:2311:114	General:CT mismatch side 2 M1ph		0.000 to 100.000	0.000

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:115	General:CT mismatch side 3 M3ph 1		0.000 to 100.000	0.000
_:2311:116	General:CT mismatch side 3 M3ph 2		0.000 to 100.000	0.000
_:2311:117	General:CT mismatch side 3 M3ph 3		0.000 to 100.000	0.000
_:2311:118	General:CT mismatch side 3 M3ph 4		0.000 to 100.000	0.000
_:2311:119	General:CT mismatch side 3 M1ph		0.000 to 100.000	0.000
_:2311:120	General:CT mismatch side 4 M3ph 1		0.000 to 100.000	0.000
_:2311:121	General:CT mismatch side 4 M3ph 2		0.000 to 100.000	0.000
_:2311:122	General:CT mismatch side 4 M3ph 3		0.000 to 100.000	0.000
_:2311:123	General:CT mismatch side 4 M3ph 4		0.000 to 100.000	0.000
_:2311:124	General:CT mismatch side 4 M1ph		0.000 to 100.000	0.000
_:2311:125	General:CT mismatch side 5 M3ph 1		0.000 to 100.000	0.000
_:2311:126	General:CT mismatch side 5 M3ph 2		0.000 to 100.000	0.000
_:2311:127	General:CT mismatch side 5 M3ph 3		0.000 to 100.000	0.000
_:2311:128	General:CT mismatch side 5 M3ph 4		0.000 to 100.000	0.000
_:2311:129	General:CT mismatch side 5 M1ph		0.000 to 100.000	0.000
_:2311:183	General:CT mismatch M1ph		0.000 to 100.000	0.000
_:2311:130	General:CT mismatch S1 M3ph 1 N		0.000 to 100.000	0.000
_:2311:131	General:CT mismatch S1 M3ph 2 N		0.000 to 100.000	0.000
_:2311:132	General:CT mismatch S1 M3ph 3 N		0.000 to 100.000	0.000
_:2311:133	General:CT mismatch S1 M3ph 4 N		0.000 to 100.000	0.000
_:2311:134	General:CT mismatch side 1 M1ph N		0.000 to 100.000	0.000
_:2311:176	General:CT mismatch S2 M3ph 1 N		0.000 to 100.000	0.000
_:2311:135	General:CT mismatch S2 M3ph 2 N		0.000 to 100.000	0.000
_:2311:136	General:CT mismatch S2 M3ph 3 N		0.000 to 100.000	0.000
_:2311:137	General:CT mismatch S2 M3ph 4 N		0.000 to 100.000	0.000
_:2311:177	General:CT mismatch side 2 M1ph N		0.000 to 100.000	0.000

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:138	General:CT mismatch S3 M3ph 1 N		0.000 to 100.000	0.000
_:2311:139	General:CT mismatch S3 M3ph 2 N		0.000 to 100.000	0.000
_:2311:140	General:CT mismatch S3 M3ph 3 N		0.000 to 100.000	0.000
_:2311:141	General:CT mismatch S3 M3ph 4 N		0.000 to 100.000	0.000
_:2311:178	General:CT mismatch side 3 M1ph N		0.000 to 100.000	0.000
_:2311:142	General:CT mismatch S4 M3ph 1 N		0.000 to 100.000	0.000
_:2311:143	General:CT mismatch S4 M3ph 2 N		0.000 to 100.000	0.000
_:2311:144	General:CT mismatch S4 M3ph 3 N		0.000 to 100.000	0.000
_:2311:145	General:CT mismatch S4 M3ph 4 N		0.000 to 100.000	0.000
_:2311:179	General:CT mismatch side 4 M1ph N		0.000 to 100.000	0.000
_:2311:146	General:CT mismatch S5 M3ph 1 N		0.000 to 100.000	0.000
_:2311:147	General:CT mismatch S5 M3ph 2 N		0.000 to 100.000	0.000
_:2311:148	General:CT mismatch S5 M3ph 3 N		0.000 to 100.000	0.000
_:2311:149	General:CT mismatch S5 M3ph 4 N		0.000 to 100.000	0.000
_:2311:180	General:CT mismatch side 5 M1ph N		0.000 to 100.000	0.000
_:2311:184	General:CT mismatch M1ph N		0.000 to 100.000	0.000
_:2311:195	General:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned
_:2311:151	General:MU-ID Side 1 Mp3ph 1		0 to 100	0
_:2311:152	General:MU-ID Side 1 Mp3ph 2		0 to 100	0
_:2311:153	General:MU-ID Side 1 Mp3ph 3		0 to 100	0
_:2311:154	General:MU-ID Side 1 Mp3ph 4		0 to 100	0
_:2311:155	General:MU-ID Side 1 Mp1ph		0 to 100	0
_:2311:156	General:MU-ID Side 2 Mp3ph 1		0 to 100	0
_:2311:157	General:MU-ID Side 2 Mp3ph 2		0 to 100	0

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:158	General:MU-ID Side 2 Mp3ph 3		0 to 100	0
_:2311:159	General:MU-ID Side 2 Mp3ph 4		0 to 100	0
_:2311:160	General:MU-ID Side 2 Mp1ph		0 to 100	0
_:2311:161	General:MU-ID Side 3 Mp3ph 1		0 to 100	0
_:2311:162	General:MU-ID Side 3 Mp3ph 2		0 to 100	0
_:2311:163	General:MU-ID Side 3 Mp3ph 3		0 to 100	0
_:2311:164	General:MU-ID Side 3 Mp3ph 4		0 to 100	0
_:2311:165	General:MU-ID Side 3 Mp1ph		0 to 100	0
_:2311:166	General:MU-ID Side 4 Mp3ph 1		0 to 100	0
_:2311:167	General:MU-ID Side 4 Mp3ph 2		0 to 100	0
_:2311:168	General:MU-ID Side 4 Mp3ph 3		0 to 100	0
_:2311:169	General:MU-ID Side 4 Mp3ph 4		0 to 100	0
_:2311:170	General:MU-ID Side 4 Mp1ph		0 to 100	0
_:2311:171	General:MU-ID Side 5 Mp3ph 1		0 to 100	0
_:2311:172	General:MU-ID Side 5 Mp3ph 2		0 to 100	0
_:2311:173	General:MU-ID Side 5 Mp3ph 3		0 to 100	0
_:2311:174	General:MU-ID Side 5 Mp3ph 4		0 to 100	0
_:2311:175	General:MU-ID Side 5 Mp1ph		0 to 100	0
_:2311:185	General:MU-ID MA1ph		0 to 100	0
_:2311:187	General:Use tap changer position		• no • yes	yes
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70

Addr.	Parameter	C	Setting Options	Default Setting
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	yes
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	2.0
_:11041:109	I-DIFF:Max. perm. Start. time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s; ∞	0.30 s
_:11041:130	I-DIFF:Crossblk. time add-on st.		0.00 s to 2.00 s; ∞	0.30 s
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no

6.6.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I restr.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I restr. operate phA	MV	O
_:2311:315	General:I restr. operate phB	MV	O
_:2311:316	General:I restr. operate phC	MV	O
_:2311:317	General:Adapt. adjustm. inrst.	SPS	O
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Incr. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:312	I-DIFF:Blocked by ext. fault	ACT	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:54	I-DIFF fast:Inactive	SPS	O
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:56	I-DIFF fast:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

6.7 Line Differential Protection

6.7.1 Overview of Functions

Line differential protection (ANSI 87L):

- Is a selective short-circuit protection for overhead lines, cables, and busbars with single-side and multi-side infeed in radial, looped, or meshed systems
- Allows simultaneous tripping on line ends if short circuits occur
- Works strictly phase-selectively

NOTE

When using the differential protection functions in a transformer differential protection, the current data format requirements of the line protection must be considered. These can be found in the Line Protection manual (C53000-G5040-C010).

6.7.2 Function Description

The line differential protection operates on the basis of current comparison (Kirchhoff's current law). For this a device has to be installed at each end of the area to be protected. The devices exchange their measurands via communication connections. Each device performs the current comparison with these measurands and trips the assigned circuit breaker if there is an internal short circuit.

Apart from normal lines, the line differential protection can also protect lines with a transformer in block connection. The current transformers selectively delimit the protection range. By using the inrush-current detection function and the adaptive method of measurement for the line differential protection, the stages can be stabilized to prevent tripping that may be caused by transformer inrush currents.

Measured-Value Transmission

If the protected object is spatially connected – as is the case with generators, transformers, busbars – the measurands can be processed directly. The processing is different for lines where the protection range extends from one station to another. To enable the measurands from all line ends to be processed at each line end, these measurands must be transferred in a suitable form. In this way, the tripping condition can be checked at each line end, and the respective local circuit breaker can be tripped in case of a fault.

The measured values are encrypted and transmitted in digital telegrams via communication channels. For this purpose, each device features at least one interface for protection-data communication, called the protection interface in the following.

Figure 6-120 shows this principle for a line with 2 ends. Each device detects the local current and sends the information on its magnitude and phase relation to the opposite end. Thus, each device can add the currents from all ends and further process them.

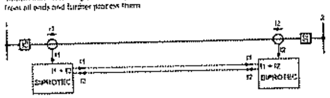

Figure 6-120 Differential Protection for a Line with 2 Ends

Constellation Measured Values

Measured-value constellations are measured values that have been predefined by Siemens with the following properties:

- They are time synchronized in the devices of a device combination
- They are exchanged across the protection interface.
- They are available on any device

You can view the constellation measured values with DIGSI 5.

In the device, current and voltage measured values are displayed in amount and phase as a percentage. 100 % conform to the rated current or the rated voltage of the line (see next figure). These measured values are recorded every 2 seconds by the devices participating in the device combination and then sent to the other respective devices. At the same time, the current and voltage values of the different devices are time-synchronous with one another.

You can find these measured values in the device under the following DIGSI mask:

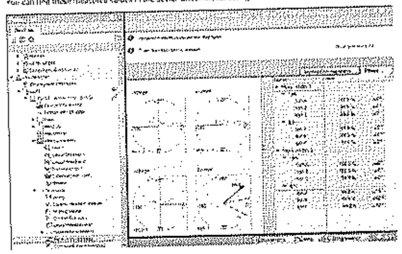

Figure 6-121 Constellation Measured Values with Phases

Measured-Value Synchronization

The devices detect the local currents asynchronously. This means that each device detects, digitizes, and preprocesses the associated currents from the current transformers at its own random processor clock. If the currents of 2 or more line ends are to be compared, all currents must be processed with the same time base. All devices in the device combination exchange their time status with each telegram. The device whose address is entered first in the device combination configuration in the protection interface functions as timing master, meaning it specifies the time frame. Each device can thus calculate the time offset due to the transmission and processing times relative to the timing master.

To achieve a sufficiently exact synchronization of the measured values, the current values are additionally provided with a time stamp before they are transmitted from one device to the others in digital telegrams. The time stamp allows a statement on the time at which the transmitted current values were valid. The receiving devices can thus carry out a fine synchronization based on the time stamp and their own time management. This means that currents detected at the same time (< 5 μs tolerance) are compared with each other.

The devices use the time stamp in the measured data telegram to monitor the transfer times in real time and take each of these into account at the respective receiving end. The frequency of the measurands is decisive for the correct calculation of the complex phasors. So that the phase comparison is synchronous, the devices also measure the frequency of the measurands constantly and feed these into the calculation when needed. If the device is connected to voltage transformers and if at least one voltage is available in sufficient magnitude, the frequency is determined from this voltage. Otherwise, the measured currents are used as the basis for the frequency determination. The devices exchange their determined frequencies with one another via the communication routes. Under these conditions, all devices operate with the updated frequency.

Adaptive Self-Stabilization

The basic principle of the differential protection is based on the precondition that, during undisturbed operation, the sum of all currents flowing into the protected object equals 0. This applies to the primary system and only then if the shunt components of current, which occur from the capacitance of the lines or the magnetization currents of the transformers and shunt reactors, are negligible. In contrast, the secondary currents offered to the devices via the current transformers contain measuring faults originating from the measuring fault of the current transformers and the input circuits of the devices themselves. Even transmission faults such as signal jitter can cause measurand deviations.

All these influences result that even in healthy operation the sum of the currents processed in the devices is not exactly 0. The differential protection is stabilized against these influences. A special method of **Adaptive self-stabilization** is applied in this context to ensure the highest possible sensitivity of the differential protection. The function calculates a restraint current I_{Stab} for this purpose.

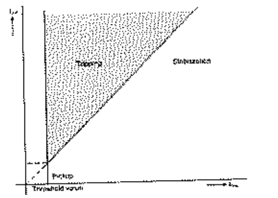

Figure 6-122 Operate Curve of the Differential Protection

Current-Transformer Faults

In order to take into account the influences of current transformer faults, each device calculates an adaptive self-stabilization value I_{Stab}. This value results from an estimated calculation of the possible local transformer faults based on the data of the local current transformers and the magnitude of the locally measured currents.

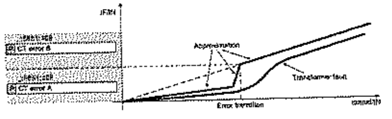

Figure 6-123 Approximation of the Current-Transformer Faults

The basis for this are the transformer data of the connected current transformers that must be entered individually for each device. Since each device transmits its estimated faults to the other devices in the device combination, each device is able to determine the sum of possible faults and use them for stabilization.

Other Measuring Faults

Other measuring faults which can occur in the device itself due to hardware tolerances, calculation tolerances, time deviations, or the quality of the measurands such as harmonics and frequency deviations are also estimated by the device and automatically adaptively increase the local self-stabilization value. The permissible variance of the transmission and processing times are also taken into account.

Time deviations are caused by residual faults when synchronizing the measurands, runtime variance of similar. GPS synchronization is used to prevent possible increases in self-stabilization in case of runtime jumps.

If an influencing variable cannot be detected – for example, the frequency if no adequate measurands are available – the device assumes the rated values by definition. In the frequency example, this means the following: If the frequency cannot be determined because no sufficient measurands are available, the device uses the rated frequency. But since the actual frequency can deviate from the rated frequency within the permissible range (± 20 %), the stabilization is automatically increased correspondingly. As soon as the frequency has been determined (100 ms max. after applying a usable measurand), the stabilization is decreased again. In practice, this has an effect if no measurand is available in the zone to be protected before the occurrence of a short circuit, for example when switching a line with line-side voltage transformers onto a fault. Since the frequency is not yet known at that time, the stabilization is increased at first until the actual frequency is determined. This can lead to a tripping delay, but only at the pickup threshold, for example, in the case of very low-current faults.

Monitoring the Differential Current

The process of adaptive self-stabilization is based on the fact that differential current faults that are caused by disturbing influences can be compensated by supplementary restraints. Thus, the process provides the highest possible sensitivity for the differential protection.

The additional dynamic monitoring of the differential current is meaningful, since there are interfering effects that cannot be detected by the devices. This includes stationary or slowly building imbalances in the transmission times in the protection interface communication over communication networks. Without external GPS time synchronization, the transmission time supervision function cannot capture the imbalances in transmission times. Therefore, the received measured values cannot be synchronized precisely and high currents passing through may cause tripping.

During operations (load operation), the behavior of the differential and restraint current must be monitored to this effect, and whether in spite of a measuring quantity the differential current approaches the operate curve in an unexpected manner and without recognizing jumps in transmission times. If the monitoring function is triggered, the indication Alarm: Diff too high is issued. In addition, a fault record is initiated in all differential protection devices.

During commissioning, ensure that the differential current in the operate curve is defined primarily by the charging current and the transformer fault ([...] Test lights). If the differential current monitoring function is already initiated during the commissioning, check first whether the setting recommendation for stage I-DIFF was followed. If stage I-DIFF is set correctly, triggering indicates a stationary imbalance of the signal

transmission times. It is the responsibility of the network operator to apply suitable measures to eliminate the causes.

Stages of Differential Protection

The differential protection has 2 preconfigured stages:

- The I-DIFF stage works with very accurate measurement. Maximum sensitivity can be achieved with it.
- The I-DIFF fast stage works in parallel with the I-DIFF stage. A very fast algorithm enables tripping decisions to be made very quickly in the event of high-current faults.

Transformer in the Protection Range

As an option, a transformer may be considered for the protection range. At each end of the protection range, for example, at each protection device in the device combination, only a few additional transformer parameters have to be entered, for example:

- Rated apparent power
- Primary voltages
- Vector groups of the relevant windings
- Any existing neutral point displacement ground connections

For this purpose, instantiate the Transformer function block in the Line differential protection function. You can find the Transformer function block in the DIGSI 5 function library, or you can select an appropriate application template.

Inrush-Current Detection

If the protection range extends beyond a transformer, a high inrush current, which flows into the protection range but does not leave it again, has to be expected when connecting the transformer. The inrush current can reach a multiple of the rated current and is characterized by a relatively high content of 2nd harmonic (twice the rated frequency), which is missing almost completely in the case of a short circuit.

The algorithm of the line differential protection recognizes the inrush current. Temporarily, the adaptive stabilization function provides an elevated restraint current, preventing any false tripping.

If the inrush-current detection function is present in the device, inrush currents are detected correctly. For this, the function block Inrush detect. from the DIGSI 5 function library must be instantiated and enabled. High inrush currents can lead to an overfunction. The inrush-current detection prevents overfunction by blocking the affected phases in all phases using the crossblock function.

Charging-Current Compensation

Distributed line or phase capacities cause a permanently capacitive charging current. This charging current has to be taken into account by the pickup values of the differential-protection stages. In cables, this charging current can reach considerable values. The charging-current compensation serves to improve the sensitivity so that maximum sensitivity can be provided even at high charging currents. For this, the function block **Ic compensat.** from the function library must be instantiated and enabled.

Emergency Mode

NOTE

When the protection device is in emergency mode, the Line differential protection function does not work.

If the Line differential protection is the main protection function in the protection device, the Line differential protection can activate the emergency mode of the device. The emergency mode is activated if one of the following conditions is met:

- Protection-interface communication is disturbed
- Line differential protection is blocked via the binary input (_:2311:82) >Block function

If emergency mode is active, the Overcurrent protection function can work as an emergency function, for example.

If the Line differential protection and Distance protection are instantiated simultaneously, you can set the distance protection zones in such a way that the blocking of the distance protection zones is disabled in case of a line differential protection outage. The blocking of the distance protection zones is disabled if one of the following conditions is met:

- Protection-interface communication is disturbed
- Line differential protection is blocked via the binary input (_:2311:82) >Block function
- Line differential protection is disabled
- Line differential protection is in the test operating mode (_:2311:308) Test all devices

Remote Tripping

The Line differential protection function, in addition to the measured values, transfers the locally generated operate indication to the line differential protection functions of the remote devices. The remote devices then generate an operate indication even if the local Line differential protection has not yet generated an operate indication. This may occur under pickup conditions at the pickup threshold.

6.7.3 Structure of the Function

The Line differential protection function is used in the Line function group.

The Line differential protection function is preconfigured at the factory with the function block (FB) General, the stage I-DIFF, and the stage I-DIFF fast.

The function blocks Ic compensat. and Transformer are available in the Global DIGSI 5 library for special applications and can be instantiated into the function.

The protection function is structured in the way that the settings in the FB General are valid for all stages.

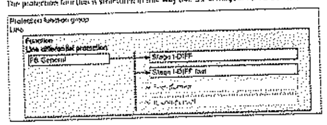

Figure 6-124 Structural Embedding of the Function

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Overall Logic

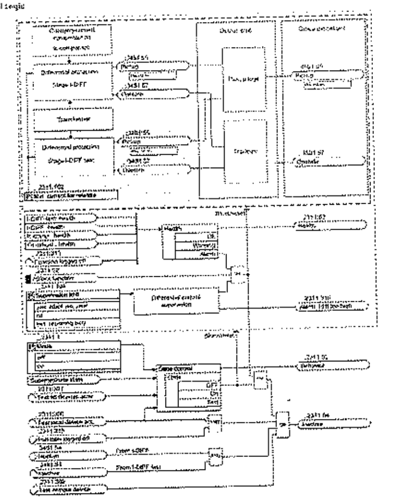

Figure 6-175 General Logic for Differential Protection Functions with 3-Pole Tripping

Mode of Operation

The Line differential protection function is composed of several subfunctions.

The core of differential protection consists of the 2 stages I-DIFF and I-DIFF fast. Both work in parallel and ensure high sensitivity or fast tripping, depending on the severity of the fault. The output signals of these

stages are picked and trip signals, which are routed to the pickup logic and the trip logic, resulting in the corresponding protection indications.

The optional I-c compensat. is available for charging current compensation. The I-c compensat. is assigned exclusively to the sensitive stage I-DIFF and ensures maximum sensitivity, even with high capacitive charging currents.

The optional FB Transformer is required when a transformer is configured in the protection range. The additional FB Transformer guarantees that amplitudes and phase angle of the measured currents at the line ends will be evaluated correctly.

6.7.4 Application and Setting Instructions - General Settings

NOTE

Keep the following hints in mind so that the line differential protection operates correctly on all line ends:

- The rated values of the line (parameter (_:9001:101) Rated current and (_:9001:102) Rated voltage) must have the identical settings at both ends of the line.
- If a transformer is installed in the line, both parameters must be set such that the rated apparent power value is the same at both ends of the line (parameter (_:9001:103) Rated apparent power).
- The rated apparent power is calculated automatically and displayed in the general line data of the Line function group (parameter _:9001:103) and in the Line differential protection function in the Transformer block (parameter Rated apparent power).

Parameter: Min. current for release

- Default setting (_:2311:102) Min. current for release = 0.00 A

With the parameter Min. current for release, you specify the minimum local current required for release of the local operate indication.

NOTE

To stabilize the line differential protection against current-transformer errors, the corresponding settings (_:8001:107) CT error changeover, (_:8001:108) CT error A, and (_:8001:109) CT error B for the current measuring points must be taken into account in the power-system data. These parameters are used exclusively by the Line differential protection function.

Parameter: Supervision Idiff

- Recommended setting value (_:2311:104) Supervision Idiff = yes: block diff. prot.

When using the parameter Supervision Idiff, you specify whether the line differential protection function operates with or without differential current monitoring.

Parameter Value	Description
no	The differential current is not monitored.
yes: reporting only	The differential current is monitored. If the differential current exceeds the monitoring threshold, and a current jump is not present, the indication Alarm: Idiff too high will be output.
yes: block diff. prot.	The differential current is monitored. If the differential current exceeds the monitoring threshold and there is no current jump, the line differential protection is blocked and the indication Alarm: Idiff too high is output.

6.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Mode		• off • on • test	off
_:2311:102	General:Min. current for release	1 A @ 100 Irated	0.030 A to 35.000 A	0.000 A
		5 A @ 100 Irated	0.00 A to 175.00 A	0.00 A
		1 A @ 50 Irated	0.000 A to 35.000 A	0.000 A
		5 A @ 50 Irated	0.00 A to 175.00 A	0.00 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.000 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	0.000 A
_:2311:104	General:Supervision Idiff		• no • yes: reporting only • yes: block diff. prot.	yes: block diff. prot.

6.7.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:507	General:>Function logoff on	SPS	I
_:2311:508	General:>Function logoff off	SPS	I
_:2311:503	General:>Test local device on	SPS	I
_:2311:504	General:>Test local device off	SPS	I
_:2311:501	General:>Test all devices on	SPS	I
_:2311:502	General:>Test all devices off	SPS	I
_:2311:319	General:Function logoff	SPC	C
_:2311:302	General:Test local device	SPC	C
_:2311:303	General:Test all devices	SPC	C
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
_:2311:315	General:Function logged off	SPS	O
_:2311:313	General:Logged off via BI	SPS	O
_:2311:314	General:Logged off via control	SPS	O
_:2311:300	General:Test local device act.	SPS	O
_:2311:306	General:BI: Test local device	SPS	O
_:2311:307	General:Cnt: Test local device	SPS	O
_:2311:301	General:Test all devices activ	SPS	O
_:2311:304	General:BI: Test all devices	SPS	O
_:2311:305	General:Cnt: Test all devices	SPS	O
_:2311:392	General:Test remote device	SPS	O
_:2311:316	General:Alarm: Idiff too high	SPS	O

6.7.7 Stage I-DIFF

6.7.7.1 Description

Logic of the Stage

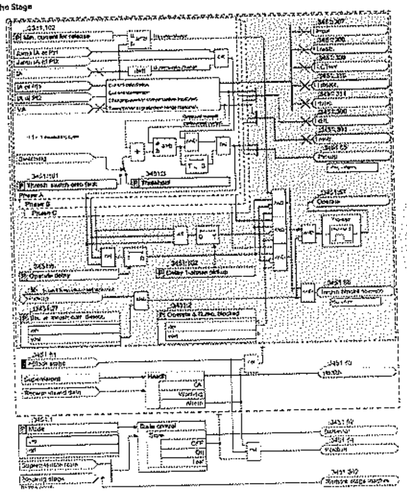

Figure 6-176 Logic of the I-DIFF Stage

Mode of Operation

The I-DIFF stage is the sensitive stage of differential protection. The principle of the I-DIFF stage is comparison of the current phasors. Usable current phasors are available after 1 period has elapsed following the occurrence of a fault event. The I-DIFF fast stage, which operates in parallel, is responsible for fast tripping in the event of high-current faults.

The measurands are analyzed separately for each phase. Each device calculates an I_{diff} differential current from the sum of the current phasors which are calculated at each end of the protected object and transmitted to the other ends. Its value corresponds to the fault current which the differential-protection system sees. Ideally that is the short-circuit current. In correct operation, it is small and corresponds to the capacitive charging current in lines in a first approximation. If charging-current compensation is active, the maximum sensitivity is achieved and the pickup value can be set considerably smaller.

The I_{rest} restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring faults at the ends of the protected object and is calculated adaptively from the current measurands and the set substation settings. To this end, the maximum fault of the current transformers in the rated range or the short-circuit current range is multiplied by the presently flowing current at each end of the protected object and transmitted to the other ends together with the determined internal faults. This means that the restraint current I_{rest} always reflects the maximum possible measuring faults in the differential-protection system.

Optional functions such as charging-current compensation (increased sensitivity) and transformer in the protection range are automatically considered when the differential and stabilization currents are calculated.

Pickup of the Stage

The pickup characteristic of the differential protection (see Figure 6-177) results from the stabilization characteristic curve $I_{diff} = I_{rest}$ (45° line) which is cut below the setting value of the Threshold parameter. It complies with the equation

I_{rest} = Threshold + Σ (current-transformer faults and other measuring faults).

If the measured differential current exceeds the pickup threshold (Threshold) and the maximum possible measuring faults, there is an internal fault (dimmed area in Figure 6-177).

In case of an internal fault, you can define an additional criterion for local tripping release using the parameter Min. current for release.

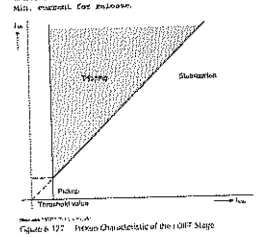

Figure 6-177 Pickup Characteristic of the I-DIFF Stage

Pickup upon Switching

When switching on longer, unloaded cables, overhead lines, and resonant-grounded lines, pronounced higher frequency compensating processes can occur. These are strongly dampened by digital filters of the differential protection. With the parameter Thresh. switch onto fault, you can prevent single-end pickup of the line differential protection in case of switching. The parameter Thresh. switch onto fault always becomes effective as soon as a device in the device combination has detected that its end is switched after a dead time. All devices in the device combination are then changed over to this pickup value for the duration of the closure detection. You can find more detailed information in chapter 5.5.4.7 Closure Detection.

In addition, for the switching of transformers and shunt reactors, the device features an inrush-current detection function via which blocking of the affected phase of the differential protection is possible. You can find more detailed information in chapter 6.51 Inrush-Current Detection.

Inrush-Current Detection

You can find the inrush-current detection function in the Global DIGSI 5 library under Line FG → Inrush detect.. Add this functionality to the Line function group (under DIGSI 5 project tree → Name of the device → Settings → Line).

The parameter Blk. w. inrush curr. detect. now also appears in the I-DIFF stage of the Line differential protection.

Fault Behavior

The Health indication is set to Alarm when fast measured-value monitoring functions (, fast sum I, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, Health is set to Alarm and Inactive is set to Yes.

Measured Value of the I-DIFF Stage

In order to clarify failures, the I-DIFF stage provides the following measured values:

Measured Value	Description
(_:3451:300) I diff.	Differential current
(_:3451:301) I restr.	Restraint current (overall restraint)
(_:3451:307) I local	Value of local current phasor
(_:3451:308) I l.restr.	Local restraint current
(_:3451:309) I l.CTerr.	Partial component of the local restraint current that considers the transformer fault.
(_:3451:310) I l.distor.	Subcomponent of the local restraint current that considers the load caused by signal distortion. Each deviation of the signal form from the sinus shape is interpreted as a signal distortion. The deviation between the actual signal form and the sinus shape will be converted to a percentage of the stabilization.
(_:3451:311) I sync.	Subcomponents of the overall restraint that are caused by faults during the time synchronization of the current phasor.

The measured values are available in the fault record. You can read out fault recordings from the device and analyze them afterwards using evaluation tools such as SIGRA. The device display shows only I diff. and I restr.. In order to find the measured values on the device, go to Main menu → Measurements → Line x → Functional measured values → Line differential protection.

Detailed information about selecting and deleting fault recordings can be found in the Operating Manual.

6.7.7.2 Application and Setting Notes for the I-DIFF Stage

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:3451:77) Blk. w. inrush curr. detect. = no

With the Blk. w. inrush curr. detect. parameter you determine whether the tripping is blocked during the detection of an inrush current. If the inrush current detection blocks tripping of the I-DIFF stage, indication Inrush blocks operate is generated.

Parameter: Threshold

- Recommended setting value (_:3451:3) Threshold = 0.300 A

With the Threshold parameter, you set the pickup threshold for the I-DIFF stage. The total current flowing into the protection range during a short circuit is decisive, that is, the total fault current, regardless of how it divides among the ends of the protected object.

Parameter: Thresh. switch onto fault

- Recommended setting value (_:3451:101) Thresh. switch onto fault = 0.300 A

With the Thresh. switch onto fault parameter, you set the pickup threshold for the I-DIFF stage during a detected connection.

A setting of 3 times to 4 times the stationary charging current generally ensures the stability of the protection when switching.

If you set the parameter in exactly the same way as the parameter Threshold, the parameter Thresh. switch onto fault is ineffective.

Parameter: Delay 1-phase pickup

- Recommended setting value (_:3451:102) Delay 1-phase pickup = 0.04 s

If the differential protection is used in an isolated or resonant-grounded system, it has to be ensured that tripping due to the fault ignition oscillation of a simple ground fault is prevented. With the Delay 1-phase pickup parameter, you delay the pickup in case of a simple ground fault.

In extended, resonant-grounded systems, Siemens recommends using a higher setting value.

NOTE

This parameter is only effective for resonant grounded/isolated neutral point treatment!

Parameter: Operate delay

- Recommended setting value (_:3451:6) Operate delay = 0.00 s

In special cases, it can be advantageous to delay the tripping of the differential protection with an additional time stage, for example for reverse interlocking. The time delay is started when an internal fault has been detected.

6.7.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I-DIFF				
_:3451:1	I-DIFF:Mode		• off • on	on
_:3451:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:3451:27	I-DIFF:Blk. w. inrush curr. detect		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:3451:3	I-DIFF:Threshold	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 1.6 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 1.6 Irated	0.500 A to 100.000 A	1.500 A
_:3451:101	I-DIFF:Thresh. switch onto fault	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 1.6 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 1.6 Irated	0.500 A to 100.000 A	1.500 A
_:3451:102	I-DIFF:Delay 1-phase pickup		0.00 s to 0.50 s	0.04 s
_:3451:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s

6.7.7.4 Information List

No.	Information	Data Class (Type)	Type
I-DIFF			
_:3451:81	I-DIFF:>Block stage	SPS	I
_:3451:54	I-DIFF:Inactive	SPS	O
_:3451:302	I-DIFF:Remote stage inactive	SPS	O
_:3451:52	I-DIFF:Behavior	ENS	O
_:3451:53	I-DIFF:Health	ENS	O
_:3451:55	I-DIFF:Pickup	ACD	O
_:3451:57	I-DIFF:Operate	ACT	O
_:3451:60	I-DIFF:Inrush blocks operate	ACT	O
_:3451:300	I-DIFF:I diff.	WYE	O
_:3451:301	I-DIFF:I restr.	WYE	O
_:3451:307	I-DIFF:I local	WYE	O
_:3451:308	I-DIFF:I restr.	WYE	O
_:3451:309	I-DIFF:I-LCTerr.	WYE	O
_:3451:310	I-DIFF:I-Ldiffor	WYE	O
_:3451:311	I-DIFF:I sync.	WYE	O

6.7.8 Stage I-DIFF Fast

6.7.8.1 Description

Logic of the Stage

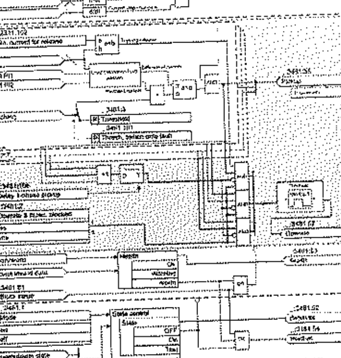

Figure 6-128 Logic of the I-DIFF Fast Stage

Mode of Operation

The I-DIFF fast stage is the differential-protection stage that is optimized for fast operate times in the event of high-current faults. It is superimposed on the I-DIFF stage. The measurands are also analyzed separately for each phase. Fast tripping for high-current faults is achieved with a procedure based on filtered instantaneous values. Since this procedure is not able to provide stabilization against signal distortions (for example, current-transformer saturation) that can occur during high-current external faults, a decision on internal or external

fault has to be made before the possible saturation occurs. It is assumed that the current transformers do not yet go into saturation at least for the duration of one integration interval (5 ms) after fault inception. Above a given passing current level (> 2.5 pickup value, local measurement), the decision for external fault is made automatically and the I-DIFF fast stage is blocked. If saturation occurs for one or more current transformers that define the protection range, this blocking is maintained and the differential caused by saturation is thus neutralized. The I-DIFF fast stage is normally set to be higher than the rated current. In this way, the influence of charging currents and cross-flow currents of transformers (fixed and transient) is suppressed.

Otherwise, the I-DIFF fast stage works in the same way as the sensitive I-DIFF stage. Each device calculates an I_{diff} differential current for each phase from the sum of the filtered instantaneous values, which are calculated at each end of the protected object and transmitted to the other ends. Its value corresponds to the fault current which the differential protection system sees, ideally that is the short-circuit current. In correct operation, it is small and corresponds to the capacitive charging current in lines in a first approximation.

The I_{rest} restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring faults at the ends of the protected object and is calculated adaptively from the current measurands and the set substation settings. To this end, the maximum faults of the current transformers in the rated range or the short-circuit current range is multiplied by the presently flowing current in each end of the protected object and transmitted to the other ends together with the determined internal faults. Thus, means that the restraint current I_{rest} always reflects the maximum possible measuring fault in the differential-protection system.

The option of a transformer in the protection range is automatically taken into account when calculating the differential and stabilization currents. An activated charging-current compensation has no effect on the I-DIFF fast stage.

Pickup of the Stage

The decision element is the RMS value of the current. The pickup characteristic (see Figure 6-129) is derived, as for the I-DIFF stage from the stabilization characteristic $I_{diff} = I_{rest}$ (45° line), which is cut below the setting value of the parameter Threshold. It complies with the equation

I_{rest} = Threshold + Σ (current-transformer fault and other measuring faults).

If the measured differential current exceeds the pickup threshold (Threshold) and the maximum possible measuring faults, there is an internal fault (see Figure 6-129).

In case of an internal fault, you can define an additional criterion for local tripping release using the parameter Min. current for release.

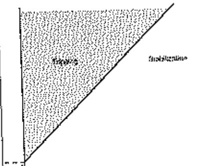

Figure 6-129 Pickup Characteristic of the I-DIFF Fast Stage

Pickup upon Switching

When switching on longer, unloaded cables, overhead lines, and resonant-grounded lines, pronounced higher-frequency compensating processes can occur.

As the Threshold of the I-DIFF fast stage is set significantly higher than the Threshold of the I-DIFF stage, switching operations do not lead to a false pickup of the I-DIFF fast stage.

For the switching operations mentioned above, it can make sense to set the parameter Thresh. switch onto fault higher than the Threshold of the I-DIFF fast stage. This reliably prevents a false pickup of the I-DIFF fast stage. The parameter Thresh. switch onto fault always becomes effective as soon as a device in the device combination detects that its end is switched after a dead time. All devices in the device combination are then changed over to this pickup value for the duration of the closure detection (Action time after closure parameter).

You can find more detailed information in chapter 5.5.4.7 Closure Detection.

Fault Behavior

The Health indication is set to Alarm when fast measured-value monitoring functions (fast sum i, analog-digital converter) signal a fault or when invalid data are received via the protection interface. The validity of the currents used as well as the validity of the data received via the protection interface are monitored continuously. If persistent faults are detected, Health is set to Alarm and Inactive is set to Yes.

6.7.8.2 Application and Setting Notes for the I-DIFF Fast Stage

Parameter: Threshold

- Recommended setting value (_:3481:3) Threshold = 1.000 A

With the Threshold parameter, you set the pickup threshold for the I-DIFF fast stage.

Since this stage responds very quickly, pickup in response to capacitive charging currents (for lines), inductive excitation currents (for transformers or shunt reactors) – including during switching procedures – must be excluded. This also applies when charging-current compensation is switched on, because this is not effective for the I-DIFF fast stage. The pickup value should be set higher than the load current (max. $1.2 \cdot I_N$ to $2 \cdot I_N$).

In resonant-grounded systems, the value must not fall below the value of the non-restraint grounded ground fault current. This value results from the total capacitive ground-fault current without taking into account the arc-suppression coil. Since the arc-suppression coil has to compensate for approximately the total capacitive ground-fault current, its rated current can approximately be taken as a basis. For transformers, set $I_{N,transf}/u_{sc}$.

A final dynamic check of the pickup thresholds is performed during commissioning.

Parameter: Thresh. switch onto fault

- Recommended setting value (_:3481:101) Thresh. switch onto fault = 1.000 A

With the Thresh. switch onto fault parameter, you set the pickup threshold for the I-DIFF fast stage during a detected connection.

If bushing-type current transformers are used for a transformer in the line section to be protected, leakage flux through the bushing-type current transformers can occur during switch-on after an external fault. These leakage fluxes can corrupt the secondary current and cause the I-DIFF fast stage to malfunction. If bushing-type current transformers are used, the pickup value on switching should be set to 2 to 3 times the setting value of the threshold value of the stage.

If you set the parameter in exactly the same way as the parameter Threshold, the parameter Thresh. switch onto fault is ineffective.

Parameter: Delay 1-phase pickup

- Recommended setting value (_:3481:106) Delay 1-phase pickup = 0.04 s

If the differential protection is used in an isolated or resonant-grounded system, it has to be ensured that tripping due to the fault ignition oscillation of a simple ground fault is prevented. With the Delay 1-phase pickup parameter, you delay the pickup in case of a simple ground fault.

In extended, resonant-grounded systems, Siemens recommends using a higher setting value.

NOTE

This parameter is only effective for resonant-grounded/isolated neutral-point treatment!

6.7.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I-DIFF fast				
_:3481:1	I-DIFF fast:Mode		• off • on	on
_:3481:2	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no
_:3481:3	I-DIFF fast:Threshold	1 A @ 100 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 100 Irated	4.000 A to 500.000 A	5.000 A
		1 A @ 50 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 50 Irated	4.000 A to 500.000 A	5.000 A
		1 A @ 1.6 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 1.6 Irated	4.000 A to 500.000 A	5.000 A
_:3481:101	I-DIFF fast:Thresh. switch onto fault	1 A @ 100 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 100 Irated	4.000 A to 500.000 A	5.000 A
		1 A @ 50 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 50 Irated	4.000 A to 500.000 A	5.000 A
		1 A @ 1.6 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 1.6 Irated	4.000 A to 500.000 A	5.000 A
_:3481:106	I-DIFF fast:Delay 1-phase pickup		0.00 s to 0.50 s	0.04 s

6.7.8.4 Information List

No.	Information	Data Class (Type)	Type
I-DIFF fast			
_:3481:81	I-DIFF fast:>Block stage	SPS	I
_:3481:54	I-DIFF fast:Inactive	SPS	O
_:3481:302	I-DIFF fast:Remote stage inactive	SPS	O
_:3481:52	I-DIFF fast:Behavior	ENS	O
_:3481:53	I-DIFF fast:Health	ENS	O
_:3481:55	I-DIFF fast:Pickup	ACD	O
_:3481:57	I-DIFF fast:Operate	ACT	O

6.7.9 Pickup and Tripping

6.7.9.1 Pickup Logic

The pickup logic combines the pickup indications of the I-DIFF and I-DIFF fast stages in a phase-segregated manner and forms the pickup group indications of the Line differential protection function.

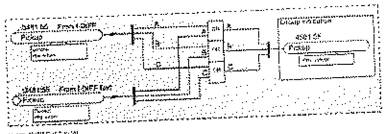

Figure 6-130 Pickup Logic

6.7.9.2 Trip Logic

The trip logic combines the operate indications of the I-DIFF and I-DIFF fast stages and of the remote trip and forms the tripping group indication of the Line differential protection function.

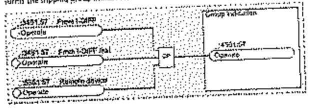

Figure 6-131 Trip Logic

6.7.9.3 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_4501.55	Group indicat.:Pickup	ACD	O
_4501.57	Group indicat.:Operate	ACT	O

6.7.10 Remote Tripping

6.7.10.1 Description

The Line differential protection function contains the remote tripping functionality.

The Remote tripping forms an internal, phase segregated operate indication through the OR operation of the operate indications in the I-DIFF and I-DIFF fast stages. This internal, phase-segregated operate indication is not available in the information routing in DIGSI 5, but instead, it is sent to the line differential protection functions in the remote devices in the device combination.

If a remote device receives a remote operate indication, the remote tripping functionality generates the (_:5551:57) Operate indication.

You can find the remote tripping indications in the DIGSI 5 information routing under Line → Line differential protection → Remote tripping

6.7.10.2 Information List

No.	Information	Data Class (Type)	Type
Remote trip			
_5551:54	Remote trip.:Inactive	SPS	O
_5551:52	Remote trip.:Behavior	ENS	O
_5551:53	Remote trip.:Health	ENS	O
_5551:57	Remote trip.:Operate	ACT	O

6.7.11 Functional Test of the Line Differential Protection

The line differential protection offers 2 types of tests:

- Test of the differential protection in a local device
- Test of the entire differential protection in all devices

You can test the Line differential protection function only locally on a device. You control the test mode with the controllable (_:2311:300) Test local device. If you select this operating mode, the Line differential protection becomes ineffective in all the other devices of the device combination. In the device to be tested locally, the Line differential protection remains effective. The locally installed and measured current is seen as differential current. Thereby, you can check the tripping behavior on the local device. Note, that the operate indications from the Line differential protection do not lead to the control of the device relay.

With the (_:2311:308) Test all devices test mode, you can check the Line differential protection function with all the devices of the device combination. You can check the reaction of the Line differential protection to parameter changes before actual operation. In the DIGSI 5, you can check the actual operating point in the differential protection characteristic curve (see Figure 6-138).

In both test modes, the device relays are not operated. If the device relays are to be operated, you must set this as follows in DIGSI or on the device:

- In DIGSI 5 under Settings → Device settings → Test support.
  Set a check mark for parameter (_:151) Oper.bin.outp. under test.
- On the device, under Settings → General → Test support → (_:151) Oper.bin.outp. under test

For both test modes, all indications are marked with a test bit.

Test of the Differential Protection in a Local Device

You can switch the test of the local differential protection function on or off in the following way:

- Via the operating dialog in DIGSI (online)
- Via the on-site operation panel
- Via the binary inputs >Test local device on and >Test local device off

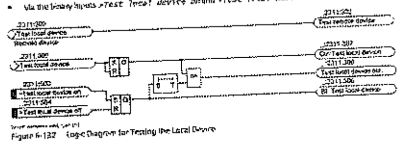

Figure 6-132 Logic Diagram for Testing the Local Device

The indications Ctrl:Test local device or BI: Test local device show in which way the test was switched on. If a device test was initiated by DIGSI or via the communication interface, then the indication (_:2311:307) Ctrl:Test local device is issued.

If the test is activated, the local differential protection function operates in test mode. This is signaled via the indications Test local device act. as well as Behavior (I-DIFF test) and Behavior (I-DIFF fast test). The differential protection functions in the other devices become inactive and report this state with the indications Inactive and Test remote device.

You can activate the operating mode manually in the following way:

- DIGSI, Online access → Interface → Device → Device Information
- On-site operation panel: Main menu → Device functions → Line 1 → Line differential protection

With a test switch, you can activate the binary inputs and switch over the current inputs of the protection device to a current generator.

The following diagrams show potential variants on how to control binary inputs.

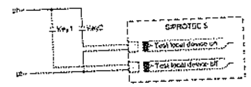

Figure 6-133 External Push-Button Wiring for Controlling the Test of the Local Device

If a control switch is used, route the binary input >Test local device on as H (active with voltage) and the binary input >Test local device off as L (active without voltage)

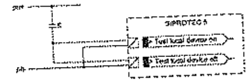

Figure 6-134 External Switch Wiring for Controlling the Test of the Local Device

Test of the Entire Differential Protection in All Devices

You can switch the test of the entire differential protection function in all devices on or off in the following way:

- Via the operating dialog in DIGSI (online)
- Via the on-site operation panel
- Via the binary inputs >Test all devices on and >Test all devices off:

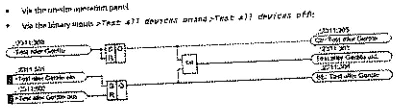

Figure 6-135 Logic Diagram for the Test of All Devices

The indications Ctrl: Test all devices or BI: Test all devices show in which way the test was started. If the test is activated, the differential protection function in all devices operates in test mode. This is signaled via the indications Test all devices active and Behavior (I-DIFF test) and Behavior (I-DIFF fast test). In this state, the differential protection may be tested.

> **NOTE**
> The test of all devices cannot be set and will be rejected if the local differential protection functions are already logged off.

You can activate the operating mode manually in the following way:

- DIGSI: Online access → Interface → Device → Device Information
- On-site operation panel: Main menu → Device functions → Line 1 → Line differential protection

The following diagrams show possible variants of activation of the test-operation type through control of binary inputs.

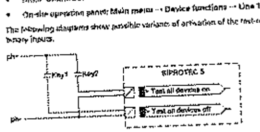

Figure 6-136 External Push-Button Wiring for Controlling the Test of All Devices

If a control switch is used, route the binary input >Test all devices on as H (active with voltage) and the binary input >Test all devices off as L (active without voltage).

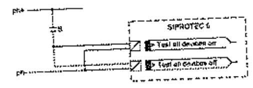

Figure 6-137 External Switch Wiring for Controlling the Test of All Devices

Checking the Differential and Restraint Current

You can check the differential and restraint currents directly on the device or by means of DIGSI 5.

In order to find the differential and restraint current on the device, go to Operational measured values → Measurements → Line 1 → Functional measured values → Differential protection.

When using the DIGSI 5 to check the differential and restraint current, the connection with the device must be established first. To find the operational measured values of the line differential protection, go to Name of device → Measurements → Line 1. While in the working area, the operational measured values of the function can be found under Functional measured values → Aligning differential protection.

In DIGSI 5 the operating points (OP) derived from the differential and restraint current can also be checked in the graphic display of the differential protection characteristic curve. In order to test the differential protection characteristic curve in DIGSI 5, go to the project tree Online device (Name of device) → Test Suite → Protection functions → Line 1 → Line differential protection. The operating points derived from the differential current and the restraint current are graphically displayed in the differential protection characteristic curve (see the following figure).

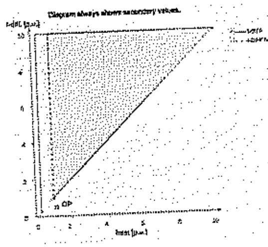

Figure 6-138 Characteristic Curve of the Differential Protection

To ensure reliable operation of the line differential protection, the operating point must be located inside the working area and clearly below the tripping lines.

If the differential current monitoring function is tripped or the operating point lies within the tripping area, proceed as follows:

- Check the pickup value for stage I-DIFF.
- Check the polarity of the current transformer.
- Verify that the differential current is generated by the primary system. Did you consider the charging current? It will be depicted as a permanent differential current.
  If these were not the causes of the differential current, the differential current can be generated by asynchronous communication networks. Such asynchronicity can be created by coupling larger communication networks.
  Another cause of the differential current could be unbalances in the runtimes for the protection communication that have always existed but not been noticed. This means that the transmission times for the protection data back and forth are different, as a result of which the measured values received cannot be synchronized perfectly. Hence, a differential current that might activate the operate function during increased current flow will be calculated.

6.7.12 Logging Off the Local Line Differential Protection

For some applications it may be necessary to remove and log off the line differential protection from the total topology of the line differential protection. These applications include, for example:

- Maintenance work
- System expansion
- Testing the local line differential protection

EXAMPLE:

The following line formation is protected by the line differential protection with 3 devices.

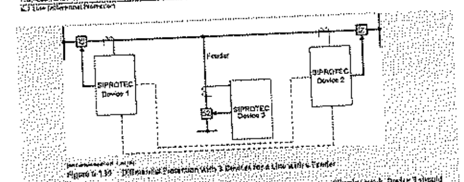

Figure 6-139 Differential Protection with 3 Devices for a Line with a Feeder

In the example, the feeder is to be decommissioned for maintenance or modification work. Device 3 should therefore also be switched off. Without additional measures, the line differential protection will no longer function and will send an indication that it is ineffective.

For this use case, the Line differential protection function must be logged off in device 3. The Line differential protection in device 3 can only be logged off if no current is flowing through the feeder. During the log-off process, device 3 checks whether the circuit breaker 3 is really open. If the Line differential protection is logged off in device 3, this is saved in the remaining devices 1 and 2 and the differential current [illegible] calculated only with the currents of the devices 1 and 2.

If device 3 is successfully logged off, you can switch it off. The logoff of device 3 is saved in the remaining devices after it is switched off. If you switch device 3 back on, [illegible] the device combination again.

> **NOTE**
> Before logging off, you must switch off the feeder protected by the local line differential protection.

Logoff Options of the Line Differential Protection

You can log off the Line differential protection function as follows:

- Via the operating dialog in DIGSI or the on-site operation panel
- Via communication through the controllable Function logoff (_:2311:319)
- Via the binary inputs, general >Function logoff on (_:2311:507) or >Function logoff off (_:2311:508)

Conditions for Logging off the Function

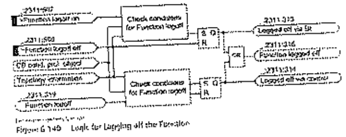

Figure 6-140 Logic for Logging off the Function

The following conditions must be fulfilled before the function is logged off:

- The current flow at the circuit breaker must be stopped. You must switch off the feeder protected by the local Line differential protection.
  The locally recorded current at the logged-off line end no longer flows into the sum of the currents. The function then only sums up the currents from the line ends that have not been logged off.
- The circuit breaker position recognition in the Circuit-breaker function group (CB) provides the circuit breaker condition via the internal signal CB state protected obj..
  If a protected object is supplied via 2 circuit breakers (CBs), for example, in case of a breaker and a half layout, then the CB state at the protected object must be determined with both circuit breakers. In this case, the Circuit breaker condition for the protected object function block performs the connection of the individual CB conditions.
  If one of the following 2 conditions is met, the CB status protected object internal signal is in the Open state.
  - All connected circuit breakers signal the Open state.
  - The >Disconnector open input is active.

  You can find more detailed information in chapter 5.5.4.6 Circuit-Breaker Condition for the Protected Object.
- Monitoring the communication topology in the device combination is only important if more than 2 devices are communicating via the protection interface. A function can only be logged off if this does not disturb the communication between the remaining devices in the device combination.

The logged-off local line differential protection can also be activated for test purposes (see 6.7.11 Functional Test of the Line Differential Protection). This has no influence or impact on the running protection interface communication.

The following diagrams show practical variants on how to control binary inputs. If you would like to use push-buttons, switch on these push buttons as shown in the following figure. With the push button Key2, you log off the function or log; with the push button Key1, you log the function on again.

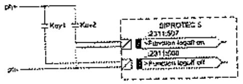

Figure 6-141 External Push-Button Wiring for Logging off the Local Line Differential Protection

If a control switch is used, route the binary input >Function logoff on as H (active with voltage) and the binary input >Function logoff off as L (active without voltage). If the switch S is closed, the function is logged off.

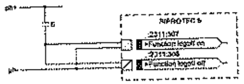

Figure 6-142 External Switch Wiring for Logging off the Local Line Differential Protection

Indications

The logged-off function reports the status (_:Function logged off) and the cause of the report.
If you have logged off the function via binary inputs, the indication Logged off via BI is issued.
If you have logged off the function via on-site operation, DIGSI 5, or the protection interface, the indication Logged off via control is issued.

6.7.13 Transformer in Protection Range

6.7.13.1 Description

If you would like any transformer (two-winding transformer or multi-winding transformer) to be taken into account in the line protection, you must instantiate the optional function block Transformer from the Global DIGSI 5 library in the Line differential protection function. You can find the Transformer function block in the Global DIGSI 5 library under FG Line → Line differential protection → Function extensions.

Enter the rated data of the transformer under FG Line → General → Rated values. The rated values affect the amount and phase of the differential current to be calculated. All measurands can be based on the rated data for the power transformer.

For each side of the transformer the rated apparent power of the transformer must be determined from the rated current and the rated voltage of the transformer side. Additionally, the respective vector groups for current and voltage and the type of grounding of the transformer neutral point have to be entered.

6.7.13.2 Application and Setting Notes

Rated Data of the Transformer

Enter the primary rated data of the transformer under FG Line → General → Rated values.

- First, enter the rated voltage of the transformer winding (side).
- Then, enter the rated current of the transformer winding. Calculate the rated current as follows from the rated apparent power and the rated voltage.

$$I_{rated} = \frac{S_{rated}}{\sqrt{3} \cdot V_{rated}}$$

To verify this, the resulting rated apparent power is shown as a write-protected parameter in the general rated values of the FG Line.

> **NOTE**
>
> The rated apparent power must adopt the same value on all ends of the protected object, since it is the basis for the current comparison of all ends.

In general, select the rated voltage of the winding facing the respective device. However, if a winding has a voltage regulating range, do not use the rated voltage of the winding, but rather the voltage which corresponds to the average current of the control area. This minimizes fault currents resulting from control.

EXAMPLE:

Transformer with the data

Vector group	Yd5
Rated apparent power S_{rated}	35 MVA
Rating	110 kV/25 kV
Control	Y side regulated ±10 %

For the regulated winding (110 kV) the following results:

Max. rated voltage V_{max} = 121 kV
Minimum voltage V_{min} = 99 kV
Calculate the setting value for the primary rated voltage as follows:

$$V_{rated} = \frac{2}{\frac{1}{V_{max}} + \frac{1}{V_{min}}} = \frac{2}{\frac{1}{121\ kV} + \frac{1}{99\ kV}} = 108.9\ kV$$

Transformer Fault Settings

If the transformer winding has a voltage control range, additional current (apparent) errors occur due to the tap changer switch position. These must be dealt with similar to transformer faults and must be considered when setting the excitation settings. Refer to the setting notes for current transformers.

You can find more detailed information in chapter 6.7.6 Application and Setting Notes for Line Differential Protection Settings.

Protection Settings

For verification purposes, the internally calculated rated apparent power will be displayed the same as a write-protected parameter. The rated apparent power is the result of the rated data of the transformer.

You can find more detailed information in chapter 6.7.1 Application and Setting Notes.

Parameter: Voltage vector group nb.

- Default setting (_:103) Voltage vector group nb. = 0

As a rule, the Voltage vector group nb. is set exactly the same as the Current vector group nb.. If the vector group of the transformer is matched via external means, for example, because matching transformers are present in the measuring current circuit and are still to be used, set Current vector group nb. = 0 at all ends. In this case, the differential protection works without a matching calculation of its own. However, the measuring voltages are then not matched beyond the transformer and thus not calculated and displayed correctly. The Voltage vector group nb. corrects this shortcoming. Here, specify the actual vector group of the transformer according to the aspects mentioned previously.

The Current vector group nb. is therefore significant for the differential protection, while Voltage vector group nb. is valid as the basis for calculating measuring voltages beyond the transformer.

Parameter: Current vector group nb.

- Default setting (_:104) Current vector group nb. = 0

Current vector group nb. is the vector group of the transformer winding facing the device. The device used at the reference side of the transformer is on the upper voltage side and has to keep the digit 0 (default). For the other windings, you must indicate the corresponding vector-group digit.

EXAMPLE:

For a transformer with the vector group Yyn5d5, set the Current vector group nb. parameter as follows:

On the Y side:	Current vector group nb. = 0
On the y side:	Current vector group nb. = 0
On the d side:	Current vector group nb. = 5

Parameter: Residual curr. elimination

- Default setting (_:105) Residual curr. elimination = yes

In case of groundings in the protection range, fault currents can flow through the current transformers in case of ground faults outside the protection range (see Figure 6-143). Possible groundings in the protection range

include a grounded transformer neutral point, grounding transformers, or an arc suppression coil. With the Residual curr. elimination parameter, you can eliminate these fault currents without particular external measures.

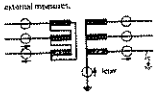

Figure 6-143 Ground Fault Outside of the Transformer

Parameter Value	Description
yes	Active elimination of residual current. Siemens recommends this setting value for applications with neutral-point grounding of the transformer in the protection range (transformer neutral point, grounding transformer, arc-suppression coil).
no	No elimination of residual current. Siemens recommends this setting value for applications without any neutral point grounding of the transformer in the protection range.

> **NOTE**
>
> If the elimination of the residual current is active, and in case of ground faults, the differential protection becomes less sensitive by a factor of 2/3.
>
> You achieve a higher degree of sensitivity only by measuring the current that flows through the neutral-point grounding of the transformer. This requires the installation of a current transformer in the neutral-point supply of the transformer, whereby its measured current can be captured by a 1-phase current input configured on the device.

6.7.13.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Transformer				
_:103	Transformer:Voltage vector group nb.		0 to 11	0
_:104	Transformer:Current vector group nb.		0 to 11	0
_:105	Transformer:Residual curr. elimination		• no • yes	yes

6.7.14 Charging-Current Compensation Ic-Compensation

6.7.14.1 Description

Logic of the Stage

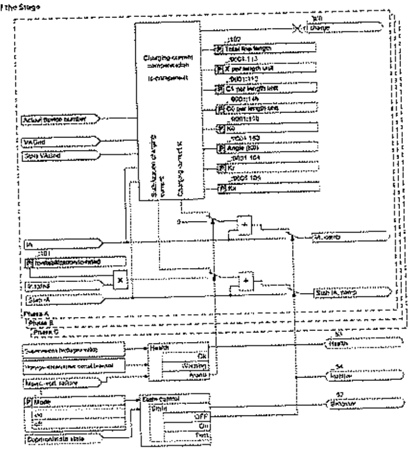

Figure 6-144 Charging-Current Compensation

Mode of Operation

The optional ΔI Ic-compensat. is available for charging-current compensation. The ΔI Ic-compensat. is assigned exclusively to the sensitive stage I-DIFF and increases the sensitivity of the I-DIFF stage even with high capacitive charging currents.

The charging current is caused by the capacitances of the overhead line or the cable and flows through the ground capacitance of the line. Due to the phase-to-ground and phase-to-phase capacitances, charging currents are flowing even in correct operation, which cause a difference of the currents at the ends of the protection range. In cables or long lines, the capacitive charging currents can reach considerable values. If the feeder-side transformer voltages are connected to the devices, the influence of the capacitive charges currents can be compensated for by calculation. The charging-current compensation specifies the actual charging current. If there are lines with 2 ends, each device performs half the charging-current compensation. When using .

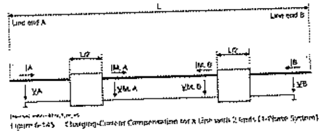

Figure 6-145 Charging-Current Compensation for a Line with 2 Ends (1-Phase System)

For correct operation, stationary charging currents can be regarded as almost constant since they only depend on the voltage and line capacitances. If you are working without charging-current compensation, take into account the charging currents in the pickup value of the I-DIFF stage. With charging-current compensation, this does not have to be taken into account here. With charging-current compensation, the stationary magnetizing currents are considered before quadrature-axis reactances. For transient inrush currents, the devices are provided with separate inrush-current detection.

> **NOTE**
>
> If you wish to work with the charging-current compensation, consider the following:
>
> - The local voltage transformers must be connected.
> - Monitor the voltage with the Measuring-voltage failure detection function. If the Measuring-voltage failure detection is not present in the Line function group, add the function to the Line function group from the Global DIGSI 5 library.
>   You can find the Measuring-voltage failure detection function in the Global DIGSI 5 library under FG Line → Supervision of secondary system → Meas.v.fail.det.
>
> If a transformer or common-mode reactors are located in the line section to be protected, charging current compensation must not be activated!

6.7.14.2 Application and Setting Notes

The rated current to rated is the capacitive charging current to be expected for the entire line and is the result of the setting values of the following parameters:

Parameters	Description
(_:101) Rated frequency	Rated frequency of the device You can find the parameter in DIGSI 5 under Settings → Device settings.

Parameters	Description
(_:9001:102) Rated voltage	Rated voltage of the line
(_:9001:112) C1 per length unit	Capacitance per unit length of the line
(_:9001:140) C0 per length unit	Capacitance per unit length of the line
(_:9001:113) X per length unit	Residual compensation factors
(_:9001:104) Kr	
(_:9001:105) Kx	
(_:9001:119) K0	You can find the parameters in DIGSI 5 under Settings → FG Line → General.
(_:9001:150) Angle (K0)	
(_:102) Total line length	Overall length of the line as a parameter of the charging current compensation. You can find the parameter in DIGSI 5 under Settings → FG Line → Line diff. prot. in the FB Ic-compensat.

For verification purposes, the rated charging current is displayed as a write-protected parameter in the function block Ic-compensat. (_:110) Rated charging current)

In the following cases, no charging current can be calculated:

- The voltages are not connected.
- The voltages are connected, but the internal supervision functions Voltage transformer circuit breaker or Measuring-voltage failure detection (Fuse Failure Monitor) detect a loss of voltage.

If one of the 2 cases occurs, the charging current compensation remains responsible for the line; however, it must switch to the conventional stabilization method (see parameter Ic-stabilization/Ic-rated).

NOTE

Before switching off the charging current compensation with the parameter Mode, you must increase the Threshold of the I-DIFF stage to 2 to 3 times Ic-rated of the line distance portion. Otherwise, undesired tripping might occur.

NOTE

You must enter additional line parameters for charging-current compensation. These include the following parameters:

- The Rated frequency
- The Rated voltage of the line
- Capacitance per unit length of the line (C1 per length unit, C0 per length unit)
- The residual compensation factors (Kr, Kx, K0, Angle (K0))
- The Total line length

Parameter: Ic-stabilization/Ic-rated

- Recommended setting value (_:101) Ic-stabilization/Ic-rated = 1.5

It is only possible to set the I-DIFF stage more sensitively by using the charging-current compensation (FB Ic-compensat.). If you use the charging-current compensation, set the Threshold of the I-DIFF stage to 1 · Ic-rated.

In case of an outage or lack of voltages, it must be ensured that the Threshold of the I-DIFF stage is increased again to 2 to 3 times Ic-rated. Do this with the parameter Ic-stabilization/Ic-rated.

With the Ic-stabilization/Ic-rated parameter, you set the stabilization charging current/rated current ratio. The setting value of the parameter Ic-stabilization/Ic-rated increases the stabilization of the I-DIFF stage by an additional component (stabilization charging current).

EXAMPLE:

In case of an outage or lack of voltages, the Threshold of the I-DIFF stage is to be increased to 2.5 times Ic-rated. The threshold of the I-DIFF stage is set to 1 · Ic-rated.

If you want to increase the threshold of the I-DIFF stage to 2.5 times, set the parameter Ic-stabilization/Ic-rated = 1.5.

In case of an outage or lack of voltages, both setting values are added to 2.5.

Since the charging current of the device must only be considered for the respective portion of the line, each device will in fact increase its normal stabilization by a value of Ic-stabilization/Ic-rated divided by the number of devices.

Parameter: Total line length

- Default setting (_:102) Total line length = 100.0 km

The parameter Total line length considers the entire length of the protected line. Thus, the overall capacity of the line and the resulting charging current of the line can be determined.

6.7.14.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ic-compensat.				
_:1	Ic-compensat.:Mode		• off • on	on
_:101	Ic-compensat.:Ic-stabilization/Ic-rated		1.0 to 4.0	1.5
_:102	Ic-compensat.:Total line length		0.1 km to 1000.0 km	100.0 km

6.7.14.4 Information List

No.	Information	Data Class (Type)	Type
Ic-compensat.			
_:54	Ic-compensat.:Inactive	SPS	O
_:52	Ic-compensat.:Behavior	ENS	O
_:53	Ic-compensat.:Health	ENS	O
_:300	Ic-compensat.:I charge	WYE	O

6.8 Stub Differential Protection

6.8.1 Overview of Functions

The Stub differential protection (ANSI 87STUB):

- Is a selective, 1 step short circuit protection for a line stub that can be tripped by a disconnector switch. It is important in 1 1/2 circuit-breaker layouts.
- Detects short circuits that lie between the current transformer and the feeder disconnector switch QB.
- Operates strictly phase segregated and permits 3-pole instantaneous high-speed tripping

The stub differential protection operates on the basis of current comparison. To do this, the current transformers that selectively limit the line range are connected to the device using 2 configured, 3-phase current measurement locations. The feedback of the disconnector's position (open) activates the stub differential protection.

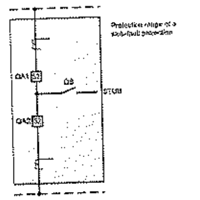

Figure 6-146 Stub Differential Protection on a 1 1/2 Circuit-Breaker Layout

6.8.2 Structure of the Function

Embedding of the Function

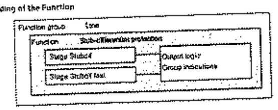

Figure 6-147 Embedding the Stub Differential Protection

Mode of Operation

The stub differential protection function is composed of the two stages: **Stubdif** and **Stubdif fast**. Both will also be referred to in the following sections as function blocks. Both stages work in parallel and ensure high sensitivity or fast tripping, depending on the severity of the fault. A release binary input (>Release func-tion) switches the stub differential protection to active. This binary input reports the position as open to the feeder disconnector switch. The output signals of these stages are pickup and trip signals, which are routed to the output logic, resulting in the corresponding protection indications.

Overall Logic

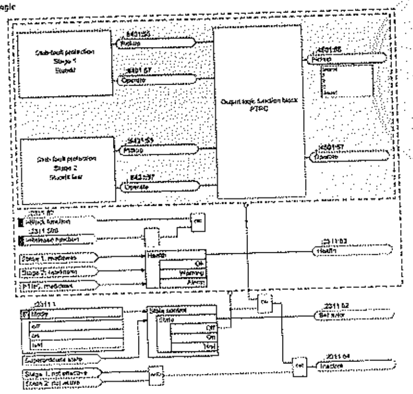

Figure 6-148 General Logic of the Stub Differential Protection

6.8.3 Function Description

Adaptive Self-Stabilization

The basic principle of differential protection rests on the presumption that, during an uninterrupted operation, the sum of all currents flowing into the protected object equal 0. Secondary currents detected by the device are burdened with measuring errors that are caused by the transmission behavior of the current transformer and

the input circuits of the device. All these influences mean that even in healthy operation the sum of the currents processed in the devices is not exactly 0. The differential protection is stabilized against these influences. A special method of adaptive self-stabilization is used in this context to ensure the highest possible sensitivity of the differential protection.

The stabilization variables are calculated from the sum of the potential faults:

Istab = Threshold + Σ (current transformer faults and other measuring errors).

If the measured differential current exceeds the pickup threshold and the maximum possible measuring error, there is an internal fault (shaded area in Figure 6-149). With the adaptive approach it is no longer necessary to assign parameters for a characteristic curve.

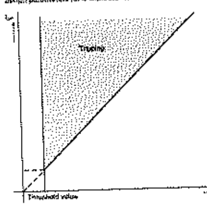

Figure 6-149 Tripping Characteristic of the Stub Differential Protection

Current-Transformer Faults

In order to take into account the influences of current transformer faults, an adaptive self-stabilization value I_{err} is calculated for each measuring point. This is the result of the sum of all current-transformer faults, which in turn are the result of the current-transformer data and the degree of currents measured on the transformer.

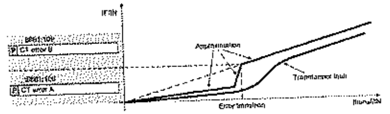

Figure 6-150 Approximation of the Current Transformer Faults

The set parameters of the transformer data apply to the configured current inputs on the device.

Other Measuring Faults

Additional measuring faults will also be estimated by the device and local self-stabilizing variables will be automatically increased.

Such measuring faults can be caused by

- Hardware and computation tolerances by the device itself
- Based on the Quality of the measurands such as harmonic components and frequency deviations.

Stages of the Stub-Differential Protection

The stub differential protection consists of 2 stages.

- The Stubdif stage works with very accurate measurement for maximum sensitivity.
- The Stubdif fast stage works in parallel with the Stubdif stage. A very fast algorithm enables tripping decisions to be made very quickly in the event of high current faults.

Both stages will be activated via a release binary input that reports the disconnector position (open) of the feeder (stub).

6.8.4 Stubdif Stage Description

Logic of the Stage

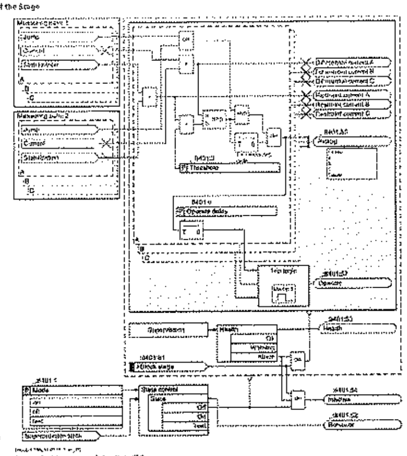

Figure 6-151 Logic of the Stubdif Stage

Mode of Operation

The Stubdif stage is the sensitive stage of the stub-differential protection. It is based on the principle of current phasor calculation. Usable current phasors are available after 1 period has elapsed following the occurrence of a fault event. The Stubdif fast stage, which operates in parallel, is responsible for fast tripping in the event of high-current errors.

All measurands are evaluated separately for each phase. The device calculates a differential current from the sum of the current phasors on the measuring inputs. The sum of the differential current is equal to the fault current, which is detected by the differential-protection system. Ideally, this is the short-circuit current. In

correct operation, it is small and corresponds to the capacitive charging current in lines in a first approximation.

The restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring errors at the ends of the protected object and is calculated adaptively from the current measurands and the set substation settings. To do this, the maximum error of the current transformers in the rated range or the short-circuit current range is multiplied with the straight flowing currents at the current transformer of the protected object.

Pickup of the Stage

The pickup characteristic of the stub-differential protection (see Figure 6-152) results from the stabilization characteristic curve Stubdif = Irest (45° line) which is cut below the setting value of the (_:8401:3) Threshold parameter. It complies with the equation

Stub = Threshold + Σ(current transformer errors and other measuring errors).

If the calculated differential current exceeds the pick-up threshold and the maximum possible measuring error, there is an internal error (shaded area in Figure 6-152).

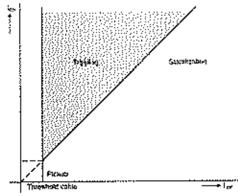

Figure 6-152 Pickup Characteristic of the Stubdif Stage

Fault Behavior

If fast measured-value supervision functions (, fast sum (, analog-digital converter) report a fault, the object (_:8401:53) Health will be set to Alarm. The validity of the used currents is constantly monitored. If persistent faults are detected, (_:8401:53) Health is set to Alarm and (_:8401:54) Inactive is set to Yes.

6.8.5 Application and Setting Notes for the Stubdif Stage

Parameter: Threshold

- Recommended setting value (_:8401:3) Threshold = 0.300 A

The pickup threshold of the differential current is set using this parameter. The total current flowing into the protection range during a short circuit is the important criterion. This is the overall fault current, regardless how the ends of the protected object are divided

Parameter: Operate delay

- Recommended setting value (_:8401:6) Operate delay = 0.00 s

In special cases, it may be advantageous to delay the tripping of the stub-differential protection with an additional time stage, for example for reverse interlocking. The time delay is started when an internal fault has been detected (_:8401:57 Pickup).

6.8.6 Stubdif Fast Stage Description

Logic of the Stage

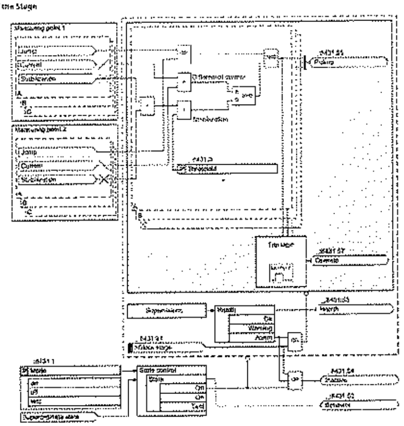

Figure 6-153 Logic of the Stubdif Fast Stage

Mode of Operation

The Stubdif fast stage is optimized for fast operate times during high current faults. It is superimposed on the Stubdif stage. The measurands are also analyzed separately for each phase. Fast tripping for high-current

errors is achieved with a procedure based on filtered instantaneous values. During this procedure, stabilization to prevent signal distortion (for example, current transformer saturation), which may occur during high current external faults, is not possible. For this reason, a decision for internal or external faults must be made prior to the onset of the potential saturation. It is assumed that the current transformers do not yet go into saturation at least for the duration of one integration interval (5 ms) after fault inception.

Above a given passing current level (7.5·pickup value, local measurement), the decision for external fault is made automatically and the Stubdif fast stage is blocked. If saturation occurs with at least one of the current transformers that limits the protection range, this blockage will remain. Thus, the difference generated by the saturation will be eliminated. Normally, the Stubdif fast is set higher than the rated current. Otherwise, the Stubdif fast stage works in the same way as the sensitive Stubdif stage. Each device calculates a differential current for each phase from the sum of the filtered instantaneous values, which are calculated at each end of the protected object. The sum of the differential current is equal to the fault current, which is detected by the differential-protection system. Ideally, this is the short-circuit current. In correct operation, it is small and corresponds to the capacitive charging current in lines in a first approximation.

The restraint current counteracts the differential current. The restraint current results from the sum of the maximum measuring errors at the ends of the protected object and is calculated adaptively from the current measurands and the set substation settings. To do this, the maximum error of the current transformers in the nominal range or the short-circuit current range is multiplied with the straight flowing currents on each end of the protected object.

Pickup of the Stage

The pickup characteristic (see Figure 6-154) is derived, as for the Stubdif stage, from the stabilization characteristic Stubdif = Irest (45° line), which is cut below the setting of the threshold value parameter. It complies with the equation

Istub = Threshold + Σ(current-transformer errors and other measuring errors).

If the calculated differential current exceeds the pickup threshold and the maximum possible measuring error, there is an internal error (shaded area in Figure 6-154).

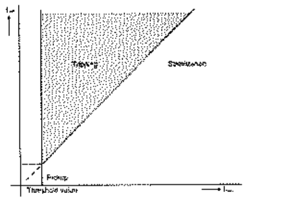

Figure 6-154 Pickup Characteristic of the Stubdif Fast Stage

Fault Behavior

If fast measured-value supervision functions (, fast sum (, analog digital converter) report a fault, the object Health will be set to Alarm. The validity of the used currents is constantly monitored. If persistent faults are detected, Health is set to Alarm and Inactive is set to Yes.

6.8.7 Application and Setting Notes for the Stubdif Fast Stage

Parameter: Threshold

- Recommended setting value (_:8431:3) Threshold = 1.000 A

This parameter sets the pickup threshold of the differential current, which must be primarily equal on all ends of the protection object.

This stage responds very quickly. For this reason, pickup during capacitive charging currents and inductive magnetization currents (for transformers or shunt reactors) - including during switching procedures - must be excluded. The pickup value should be set higher than the load current (max. $1.2 \cdot I_N$ to $2 \cdot I_N$).

6.8.8 Stage Description of the Output Logic

Output Logic

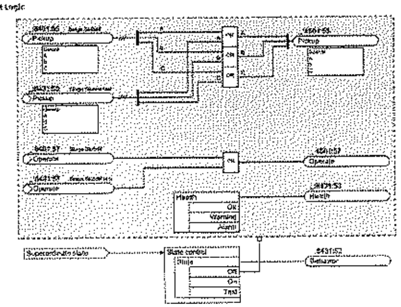

Figure 6-155 Output Logic

6.8.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:1	General:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
Stub DIFF				
_:8401:1	Stub DIFF:Mode		• off • on • test	off
_:8401:2	Stub DIFF:Operate & flt.rec. blocked		• no • yes	no
_:8401:27	Stub DIFF:Blk. w. inrush curr. detect.		• no • yes	no
_:8401:3	Stub DIFF:Threshold	1 A @ 100 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 100 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 50 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 50 Irated	0.50 A to 100.00 A	1.50 A
		1 A @ 1.6 Irated	0.100 A to 20.000 A	0.300 A
		5 A @ 1.6 Irated	0.500 A to 100.000 A	1.500 A
_:8401:6	Stub DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Stub DIFF fast				
_:8431:1	Stub DIFF fast:Mode		• off • on • test	off
_:8431:2	Stub DIFF fast:Operate & flt.rec. blocked		• no • yes	no
_:8431:3	Stub DIFF fast:Threshold	1 A @ 100 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 100 Irated	4.00 A to 500.00 A	5.00 A
		1 A @ 50 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 50 Irated	4.00 A to 500.00 A	5.00 A
		1 A @ 1.6 Irated	0.800 A to 100.000 A	1.000 A
		5 A @ 1.6 Irated	4.000 A to 500.000 A	5.000 A

6.8.10 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:81	General:>Block function	SPS	I
_:2311:500	General:>Release function	SPS	I
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Stub DIFF			
_:8401:81	Stub DIFF:>Block stage	SPS	I
_:8401:54	Stub DIFF:Inactive	SPS	O
_:8401:52	Stub DIFF:Behavior	ENS	O
_:8401:53	Stub DIFF:Health	ENS	O
_:8401:55	Stub DIFF:Pickup	ACD	O
_:8401:57	Stub DIFF:Operate	ACT	O
_:8401:[illegible]	Stub DIFF:Inrush blocks operate	ACT	O
_:8401:300	Stub DIFF:I diff.	WYE	O
_:8401:301	Stub DIFF:I rest.	WYE	O

No.	Information	Data Class (Type)	Type
Stub DIFF fast			
_8431:81	Stub DIFF fast:>Block stage	SPS	I
_8431:54	Stub DIFF fast:Inactive	SPS	O
_8431:52	Stub DIFF fast:Behavior	ENS	O
_8431:53	Stub DIFF fast:Health	ENS	O
_8431:55	Stub DIFF fast:Pickup	ACD	O
_8431:57	Stub DIFF fast:Operate	ACT	O
Group indicat.			
_4501:55	Group indicat.:Pickup	ACD	O
_4501:57	Group indicat.:Operate	ACT	O

6.9 Directional Intermittent Ground-Fault Protection

6.9.1 Overview of Functions

The function Directional intermittent ground-fault protection:

- Detects the intermittent ground faults in grounded, compensated, or isolated cable systems selectively
- Can be operated in 2 different modes:
  - Operate only by counting directional ground-current pulses
  - Operate by integration of the fault current in combination with a directional criterion by counting directional ground-current pulses

The intermittent ground faults in cable systems are frequently caused by weak insulation or water ingress in cable joints. The ground faults are characterized by the following properties:

- Intermittent ground faults show very short high ground-current pulses (up to several hundred amperes) with a duration of less than 1 ms.
- Intermittent ground faults are self-extinguishing and reignite within one half period up to several periods, depending on the power-system conditions and the fault type.
- Intermittent ground faults can persist over longer periods (several seconds to minutes) and develop to static ground faults.

6.9.2 Structure of the Function

The function Directional intermittent ground-fault protection can be used in protection function groups with current and voltage measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously.

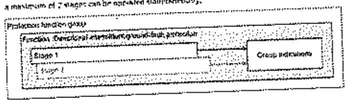

Figure 6-156 Structure/Embedding of the Function

6.9.3 Stage Description

Overview

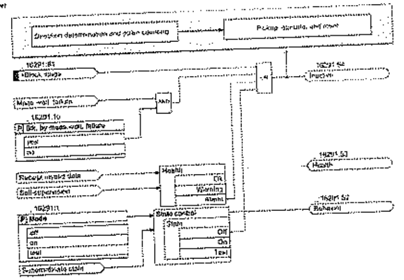

Figure 6-157 Logic of the Directional Intermittent Ground-Fault Protection

Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked-up stage will be reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Volt.-transf. c. b., which links in the tripping of the voltage-transformer circuit breaker

The Blk. by meas.-volt. failure parameter can be set so that the measuring-voltage failure detection blocks the stage or does not block it.

Logic for Direction Determination and Pulse Counting

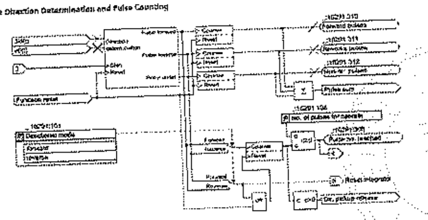

Figure 6-158 Logic Diagram of Direction Determination and Pulse Counting

(1) The input signal 3 is from Figure 6-159.

Measurement Values for Direction Determination

The function Directional intermittent ground-fault protection uses the zero-sequence active energy to determine the direction of the ground-current pulse.

The zero-sequence active energy is calculated from v0(t) and 3i0(t). The zero-sequence voltage v0(t) can either be measured via the voltage input VN or can be calculated from the sum of 3 phase-to-ground voltages. The measured value depends on the parameter Connection type of the measuring point V-3ph.

The intermittent ground-fault current 3i0(t) can either be measured via the ground-current input IN or via the sensitive ground-current input INs. It can also be calculated from the sum of the 3 phase currents. The measured value and its setting range depend on the parameter Connection type of the measuring point I-3ph.

Table 6-2 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary at Irated = 1 A)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
2 + IN	Measured	4 * Protection	0.030 A to 35.000 A
3 + IN separate		4 * Measurement	0.001 A to 1.600 A
	Measured and calculated when exceeding 1.6 A	3 * Protection, 1 * sensitive	0.001 A to 35.000 A

Direction Determination and Pulse Counting

When the RMS value of 3I0 exceeds the set threshold value (signal no. 3 in Figure 6-158), the direction determination process is started and is continuously carried out until the function resets. At first, the current pulse (current peak) detection takes place. If a current pulse is detected, the direction determination for this pulse is carried out.

The direction is determined by calculating the active zero-sequence energy of the current pulse. The active zero-sequence energy of the pulse is compared to internal threshold values resulting in the directional decision forward, reverse, or non-directional. During the ongoing intermittent ground fault, the directional results for all current pulses are counted.

Directional Mode and Directional Pulse Counter Criterion

The parameter Directional mode defines whether the function operates in forward or in reverse direction. The pulses in the specified direction are counted. If the pulse counter reaches the threshold value set in the parameter No. of pulses for operate, the signal Pulse no. reached is issued. Depending on the operating mode (Counter or Integrator and counter) of the function, the signal can immediately cause the operate of the function (Counter mode) or it is processed as directional release criteria (Integrator and counter operating mode). Refer to the further description in the following sections.

The directional pulse counter is reset when a different direction than the set Directional mode is detected. An undefined direction result does not reset the counter.

Operating Mode

2 different functional operating modes are available: Counter and Integrator and counter. You can select the different operating modes using the parameter Operating mode.

- Operating mode Counter:
  Many ground-current pulses of intermittent ground faults can result in a damage of the protected object. In this mode, the criterion for operate is only the number of directional current pulses. This is similar to the SIPROTEC 4 implementation.
- Operating mode Integrator and counter:
  An intermittent ground fault can result in thermal stress on the protected object. The magnitude and the duration of the ground-current pulses are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integration value reaches the threshold value, one criterion for the operate is fulfilled. The 2nd criterion for the operate is the ground-fault direction. The ground-fault direction is determined by counting the directional ground-current pulses.

Pickup, Operate, and Reset Logic for the Counter Mode

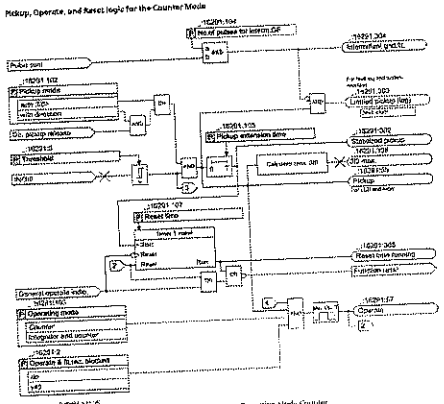

Figure 6-159 Pickup, Operate, and Reset Logic in Operating Mode Counter

(1) The internal signal 4 is from Figure 6-158.

Pickup, Operate, and Reset Logic for the Integrator and Counter Mode

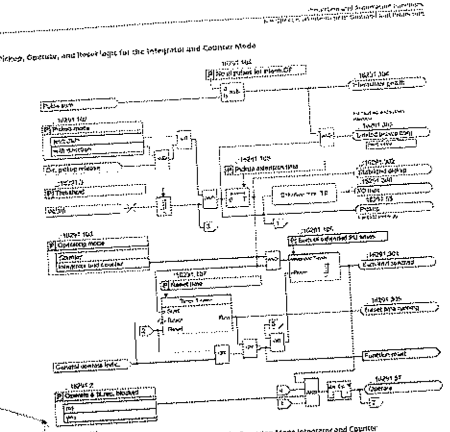

Figure 6-160 Pickup, Operate, and Reset Logic in Operating Mode Integrator and Counter

(1) The internal signal 4 and 5 are from Figure 6-159.

Measurement Value for Pickup and Integration

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonic components and the direct component (DC). Both components contribute to the thermal load.

Pickup, Limited Pickup, and Stabilized Pickup

Whenever 3I0 exceeds Threshold, the stage issues the signal Pickup. The signal is intended to be applied for LED and relay output.

Stabilized pickup is formed by prolonging the pickup indication by a settable time Pickup extension time. This stabilization is especially important for the coordination with the existing static or electromechanical overcurrent protection.

The Limited pickup (Tog) signal is intend to be applied for logging and communication interface. The Limited pickup (Tog) signal will be entered in the fault log and reported via the system interface unless the Intermittent gnd.flt. indication is given. This behavior prevents a burst of indications.

Intermittent Ground Fault Indication

The stage counts the 3I0 pulses. If the sum of forward pulse counts, reverse counts, and non-directional undefined counts is equal to or greater than No. of pulses for interm. GF, the signal Intermittent gnd.flt. is issued.

If the signal Intermittent gnd.flt. is issued, the pickup indications of some protection functions will be restrained to avoid an indication burst during an intermittent ground fault.

Operate

The conditions for issuing the signal Operate depend on the operating mode.

Operating Mode	Conditions for Issuing the Operate Signal
Counter	• The current pulse counter reached the No. of pulses for operate, which is signaled via the Pulse no. reached indication. • The pickup is active, which is signaled via the Pickup indication.
Integrator and counter	• The 3I0 current integration value reaches the predefined Sum of extended PU times, which is signaled via the Sum T limit reached indication. • The current-pulse counter reached the No. of pulses for operate, which is signaled via the Pulse no. reached indication. • The pickup is active, which is signaled via the Pickup indication.

When an opposite current pulse against the setting Directional mode is detected, the integrator T-sum and the Counter are reset.

Reset Time for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if the ground fault extinguishes and does not restrike again within a larger time, the stressed equipment can cool down. In this case, no operate is necessary. The interval between ground faults is monitored with the reset time. If a ground fault occurs, the Timer T-reset with the setting Reset time and the integrator T-sum are launched simultaneously. Unlike the integrator, each new ground current pulse restarts the reset time with its initial value. If the Timer T-reset expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. The Timer T-reset thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new ground-fault event.

Reset Conditions

Under one of the following 2 conditions, Timer T-reset is reset:
- The intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, Integrator T-sum and Counter are reset and the whole stage is reset and returns to its idle state.
- The Timer T-reset expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Maximum Value 3I0 of the Ground Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault. The statistic value 3I0 max. is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. If the function resets or operates, this value is logged via the signal 3I0 max..

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter Operate & flt.rec. blocked to yes, the operate of the stage and fault recording are blocked and the information automatically appears in the ground fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start and Stop of Fault Recording, Fault Logging, and General Pickup

The Stabilized pickup signal initiates fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the set trigger time before the Stabilized pickup signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Indications

In this case, the function uses the same mechanism as the Non-directional intermittent ground fault protection. For more information, refer to chapter Influence on Other Functions to Avoid a Burst of Signals, Page 562.

6.9.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults. For this reason, the Directional intermittent ground-fault protection function is not intended to start the Automatic reclosing function.

Routing of Pickup Signals

The signal Pickup is supposed to be routed to an LED and a relay. The signal Limited pickup (Tog) is only reported to the fault log and communication interface until the signal Intermittent gnd.flt. is issued. This scheme prevents a burst of indications.

> **NOTE**
>
> To avoid a burst of indications, do not route the signal Pickup to the operational log and to the fault log.

Parameter: Threshold

- Default setting (_:16291:3) Threshold = 1.00 A

With the parameter Threshold, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground-fault current increases.

Parameter: Directional mode

- Default setting (_:16291:101) Directional mode = forward

With the parameter Directional mode, you define if the function operates in forward or in reverse direction.

Parameter: Pickup mode

- Default setting (_:16291:102) Pickup mode = with 3I0>

With the parameter Pickup mode, you define under which conditions pickup is detected and fault logging and recording starts:
- When the parameter Pickup mode is set to with 3I0>, the signal Pickup is released without considering the ground fault direction. The signal Pickup is issued once the RMS 3I0 exceeds the threshold value.
- When the parameter Pickup mode is set to with direction, the signal Pickup is issued when at least one pulse direction is the same as the direction specified by the set value of parameter Directional mode.

Parameter: Operating mode

- Default setting (_:16291:103) Operating mode = Counter

With the parameter Operating mode, you define if the function operates in Counter or in Integrator and counter mode.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. This is a simple method which is similar to the implementation in the 7SJ SIPROTEC 4 devices. Siemens recommends using this method if no time grading or only simple time grading between protection devices (time grading of only 2 or 3 devices) is required. Time grading is then carried out by increasing the parameter value No. of pulses for operate towards the infeed.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The integrator works in the same way as for the non-directional intermittent ground fault function. This allows the same time-grading principles as for the non-directional intermittent ground fault function. Refer to this function for more description.

Parameter: No. of pulses for interm.GF

- Default setting (_:16291:104) No. of pulses for interm.GF = 3

With the parameter No. of pulses for interm.GF, you set the total number of pulse counts (forward, reverse and non-dir. pulses) at which the ground fault is considered to be intermittent. Siemens recommends using the default setting.

Parameter: Pickup extension time

- Default setting (_:16291:105) Pickup extension time = 0.10 s

With the parameter Pickup extension time, you get a prolonged and thus stabilized pickup signal. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: No. of pulses for operate

- Default setting (_:16291:108) No. of pulses for operate = 5

The pulses in the specified direction from Directional mode are counted. If the pulse counter reaches the set value of the parameter No. of pulses for operate, the directional counter criterion is fulfilled. The setting of parameter No. of pulses for operate depends on the Operating mode.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. Thus do not set the value for parameter No. of pulses for operate too small. Consider that a permanent intermittent ground fault will cause many current pulses. If no time-grading considerations are required, Siemens recommends using a value in the range of 10 to 20.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The value for parameter No. of pulses for operate to fulfill the directional criterion can be set to a rather small value in the range of 3 to 5.

Parameter: Sum of extended PU times

- Default setting (_:16291:106) Sum of extended PU times = 20.00 s

This parameter is only relevant in the operating mode Integrator and counter.

With the parameter Sum of extended PU times, you set the threshold value for the integrator. If the integration reaches Sum of extended PU times, the stage operates if the Pulse no. reached signal and the pickup state is present.

The parameter Sum of extended PU times represents one of the 5 selectivity criteria (ground-fault direction, pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on subordinate devices. It is comparable to the time grading of the overcurrent protection. The Sum of extended PU times has the shortest summation time in the radial system for the device that is closest to the intermittent ground fault and that picks up.

Parameter: Reset time

- Default setting (_:16291:107) Reset time = 300 s

With the parameter Reset time, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the Reset time, the counter and integrator are reset.

The Reset time parameter must be much higher than the setting value of the Sum of extended PU times.

Parameter: Operate & flt.rec. blocked

- Default setting (_:16291:2) Operate & flt.rec. blocked = no

With the parameter Operate & flt.rec. blocked, you can block the operate indication, the fault recording, and the fault log. In this case, a ground-fault log is created instead of the fault log.

6.9.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:16291:1	Stage 1:Mode		• off • on • test	off
_:16291:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:16291:11	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:16291:101	Stage 1:Directional mode		• forward • reverse	forward

Addr.	Parameter	C	Setting Options	Default Setting
_:16291:102	Stage 1:Pickup mode		• with 3I0> • with direction	with 3I0>
_:16291:103	Stage 1:Operating mode		• Counter • Integrator and counter	Counter
_:16291:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:16291:105	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:16291:104	Stage 1:No. of pulses for interm.GF		2 to 10	3
_:16291:106	Stage 1:Sum of extended PU times		0.00 s to 100.00 s	20.00 s
_:16291:107	Stage 1:Reset time		1.00 s to 600.00 s	300.00 s
_:16291:108	Stage 1:No. of pulses for operate		2 to 100	5

6.9.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:16291:81	Stage 1:>Block stage	SPS	I
_:16291:51	Stage 1:Inactive	SPS	O
_:16291:52	Stage 1:Behavior	ENS	O
_:16291:53	Stage 1:Health	ENS	O
_:16291:55	Stage 1:Pickup	ACD	O
_:16291:302	Stage 1:Stabilized pickup	ACD	O
_:16291:303	Stage 1:Limited pickup (Tog)	SPS	O
_:16291:304	Stage 1:Intermittent gnd.flt.	SPS	O
_:16291:301	Stage 1:Sum limit reached	SPS	O
_:16291:308	Stage 1:Pulse no. reached	SPS	O
_:16291:305	Stage 1:Reset time running	ACT	O
_:16291:57	Stage 1:Operate	ACT	O
_:16291:306	Stage 1:3I0 max.	MV	O
_:16291:310	Stage 1:Forward pulses	MV	O
_:16291:311	Stage 1:Reverse pulses	INV	O
_:16291:312	Stage 1:Non-dir. pulses		

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6.10 Non-Directional Intermittent Ground-Fault Protection

6.10.1 Overview of Functions

A typical characteristic of intermittent ground faults is that they often extinguish automatically and strike again after some time. The fault duration can last between a few milliseconds and many seconds. [illegible] faults are not detected at all or not selectively by the ordinary overcurrent protection. If pulse durations are extremely short, not all protection devices in a short-circuit path can pick up. Thus, selective tripping is not ensured.

Due to the time delay of the overcurrent protection function, such faults are too short to initiate switching off the faulted cable. The short-circuit protection can clear such ground faults selectively only if the ground faults have become permanent.

But such intermittent ground faults already bear the risk of damaging the equipment thermally. This is why SIPROTEC 5 devices feature a protection function that is able to detect such intermittent ground faults and accumulate their duration. If the sum reaches a configurable value within a certain time, the limit of the thermal rating has been reached. If intermittent ground faults are distributed over a long period or if the ground fault disappears and does not reoccur after some time, the equipment under load is expected to cool down. Tripping is not necessary in this case.

The Non-directional intermittent ground-fault protection function is used to protect against intermittent ground faults which occur, for example, in cables due to poor insulation or water ingress in cable joints.

6.10.2 Structure of the Function

The Non-directional intermittent ground-fault protection function can be used in protection function groups with current measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously. The non-preconfigured stages are shown in gray in the following figure.

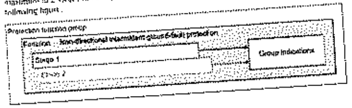

Figure 6-161 Structural Embedding of the Function

6.10.3 Stage Description

Logic

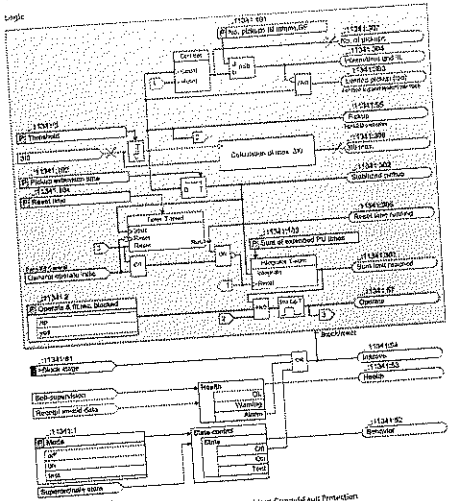

Figure 6-162 Logic of the Non-Directional Intermittent Ground-Fault Protection

Measured Value 3I0

The intermittent ground-fault function 3I0 can either be directly measured by the standard ground current input I_N or via the sensitive ground-current input I_{Ns}. It can also be calculated from the sum of the 3 phase currents. The measured value depends on the parameter Connection type of the measuring point 3-ph.

Table 6-3 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point 3-ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary at Irated = 1 A)
3-ph, Neutral	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
3 + IN	Measured	4 * Protection	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
3 + IN separate	Measured and calculated when exceeding 1.6 A	3 * Protection, 1 * sensitive	0.001 A to 35.000 A

Method of Measurement

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonic components and the direct component (DC). Both components contribute to the thermal load.

Maximum 3I0 of the Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault. The statistic value 3I0 max. is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. With the coming outgoing signal, this value is logged via the information 3I0 max.

Pickup and Intermittent Ground-Fault Indication

When 3I0 exceeds the threshold value, the pickup signals Pickup and Limited pickup (Tep) are issued. The stage generates the Stabilized pickup signal by extending the Pickup for a defined time (parameter Pickup extension time).

The stage counts the Pickup signals. If the counted number reaches the configured No. of pickups till interm. GF, the Intermittent gnd. flt. signal is issued. The signal Limited pickup (Tep) is not issued anymore after the issue of the Intermittent gnd. flt. signal.

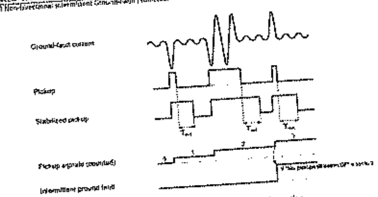

Figure 6-163 Fault Detection of the Intermittent Ground Fault Protection

T_{ep} Defined time for extending the Pickup signal

Number of Pickups

The stage counts the number of Pickup signals during the intermittent ground fault. With the operate of the stage this number is logged via the information No. of pickups.

Accumulation of the Intermittent Ground-Fault Current and Issuing the Operate Signal

An intermittent ground fault can result in thermal stress on the protected equipment. The magnitude and the duration of the ground-fault current are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integrating value reaches the predefined Sum of extended PU times, the limit of the thermal load is reached. The stage issues the signal Sum limit reached and operates when the signal Pickup is active.

Reset Timer for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if ground faults extinguish and do not restrike again within a larger time, the stressed equipment can cool down. In this case, an operation is not necessary. The interval between ground faults is monitored with the reset timer. If a ground fault occurs, the Timer T-reset with its setting Reset time is launched simultaneously with Integrator T-sum. Unlike the integrator, each new ground fault restarts the reset timer with its initial value. If Timer T-reset expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. Timer T-reset thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new fault event.

Reset Conditions

Under one of the following 2 conditions, Timer T-reset is reset:

- The intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, Integrator T-sum and Counter are reset and the whole stage is reset and returns to its idle state:

- Timer T-reset expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter Operate & flt.rec. blocked to yes, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start & Stop of Fault Recording, Fault Logging, and General Pickup

The Stabilized pickup signal initiates the fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the Stabilized pickup signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Signals

Intermittent ground faults may cause other functions, based on overcurrent measurement, to pick up, which may result in a burst of signals. In order to avoid an overflow of the fault log, a special mechanism is applied to the signals of these functions after detection of an intermittent ground fault (signal Intermittent gnd. flt.).

The special mechanism is applied for the following listed functions and other functions are not influenced:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Directional overcurrent protection, phases
- Directional overcurrent protection, ground
- Overcurrent protection, 1 phase
- Negative sequence protection with definite time characteristic curve
- Directional negative-sequence protection with definite-time delay
- Directional overcurrent protection stage with cos phi or sin phi measurement
- Directional overcurrent protection stage with 3I0 phi (V,I) measurement
- Sensitive ground current protection with 3I0

If a function picks up, normally its output signals are sent directly to the information targets, for example, the pickup signal is written to the fault log. To avoid overflow of logs due to intermittent ground faults, a special log buffer mechanism is used. If one of the preceding functions or stages picks up after an intermittent ground fault has been detected (signal Intermittent gnd. flt. has been issued), its output signals are processed as shown in the following 2 tables.

Table 6-4 Processing of the Signal Status Changes

Processing of Signal Status Changes	Description
Special buffering mechanism	The status changes of signals are written to a special buffer. This buffer can store a maximum of 2 status changes (the most recent ones) for each signal. With the pickup signal as example, if one of the preceding protection functions or stages picks up during an active Intermittent gnd. flt. signal, the pickup signal is not written in the fault log anymore unless one of the preceding functions operates. After the operation, the buffered signals are written to the information target with the original time stamp. This measure ensures that a pickup signal, although delayed, is always signaled in association with each operate command.
Discard	The signal status changes are discarded.
Pass through	The signal is forwarded to the information target without restriction. Special buffering does not apply for specific information targets as protection interface, for example, reverse interlocking, send these signals for proper operation.

Table 6-5 Information Target with Different Processing of Signal Status Changes

Information Target		Processing of Signal Status Changes
Processing of Signal Status Changes	Operational log Fault log Ground-fault log User-defined log	Special buffering mechanism
Communication interface	IEC 61850-8-1 Client/Server IEC 60870-5-103/104 DNP V3.0	Special buffering mechanism
	PDI	Pass through
Protection interface		Pass through
IEC 61850-8-1 GOOSE		Pass through
CFC		Pass through
LEDs		Pass through
Binary output		Pass through
Fault recorder		Discard
Automatic reclosing function		Discard
Circuit-breaker failure protection		Discard
Group indications		

6.10.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults as the protection function only operates after repeated detection of a fault or after the integration value reaches the predefined Sum of extended PU times. Besides this, its basic design is to prevent thermal overload. For these reasons, the intermittent ground-fault protection function is not intended to start the automatic reclosing function.

ВЯРНО С ОРИГИНАЛА

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Routing of Pickup Signals

The signal Pickup is supposed to be routed to LED and relay. The signal Extended pickup (log) is only reported to the fault log and communication interface before the signal Intermittent gnd. flt. is issued. This scheme prevents a burst of messages.

NOTE

In avoid a burst of messages, do not route the signal Pickup to the operational log and fault log.

Parameter: 3I0 Threshold

- Default setting (_:11341:3) Threshold = 1.00 A

With the Threshold parameter, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground fault current increases.

Parameter: No. pickups till interm.GF

- Default setting (_:11341:101) No. pickups till interm.GF = 3

With the parameter No. pickups till interm.GF, you set the number of counted Pickup signals after which the ground fault is considered as intermittent.

Parameter: Pickup extension time

- Default setting (_:11341:102) Pickup extension time = 0.10 s

You can get a stabilized pickup signal with the Pickup extension time parameter. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: Sum of extended PU times

- Default setting (_:11341:103) Sum of extended PU times = 20 s

With the Sum of extended PU times parameter, you set the threshold value for the integrator. If the integration reaches Sum of extended PU times, the stage operates if the pickup state is present. This Sum of extended PU times represents one of the 4 selectivity criteria (pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on adjacent feeders. It is comparable to the time grading of the overcurrent protection. The protection in the radial system which is closest to the intermittent fault and picks up, has the shortest summation time Sum of extended PU times.

Parameter: Reset time

- Default setting (_:11341:104) Reset time = 300 s

With the parameter Reset time, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the Reset time, the counter and integrator are reset.

The Reset time parameter must be much higher than the operate value of the Sum of extended PU times.

Parameter: Operate & flt.rec. blocked

- Default setting (_:11341:3) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

EXAMPLE

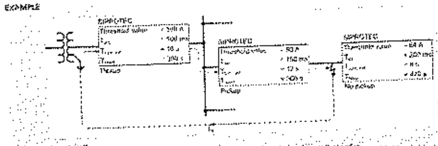

Figure 6-164 Example of Selectivity Criteria of the Intermittent Ground-Fault Protection

6.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:11341:1	Stage 1:Mode		• off • on • test	off
_:11341:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11341:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:11341:101	Stage 1:No. pickups till interm.GF		2 to 10	3
_:11341:102	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:11341:103	Stage 1:Sum of extended PU times		0.00 s to 100.00 s	20.00 s
_:11341:104	Stage 1:Reset time		1.00 s to 600.00 s	300.00 s

6.10.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:11341:81	Stage 1:>Block stage	SPS	I
_:11341:54	Stage 1:Inactive	SPS	O
_:11341:52	Stage 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:11341:53	Stage 1:Health	ENS	O
_:11341:55	Stage 1:Pickup	ACD	O
_:11341:302	Stage 1:Stabilized pickup	ACD	O
_:11341:303	Stage 1:Isolated pickup (log)	ACD	O
_:11341:301	Stage 1:Intermittent gnd flt	SPS	O
_:11341:305	Stage 1:Sum lim. reached	SPS	O
_:11341:306	Stage 1:Reset time running	SPS	O
_:11341:57	Stage 1:Operate	ACT	O
_:11341:308	Stage 1:3I0 max.	MV	O
_:11341:307	Stage 1:No. of pickups	INS	O

6.11 Sensitive Ground-Fault Detection

6.11.1 Overview of Functions

2 functions are available for ground-fault detection: A directional one that is used if, in addition to the zero-sequence current 3I0, the zero-sequence voltage V0 is also available, and a non-directional one that is used if only the zero-sequence current 3I0 is available.

The Directional sensitive ground-fault detection (ANSI 67Ns) serves:

- For directional detection of permanent ground faults in isolated or resonant-grounded systems
- For directional detection of fast extinguishing transient ground faults in isolated or resonant-grounded systems
- For determination of the faulty phase
- For detection of high-resistance ground faults in effectively (solidly) or low-resistance (semi solidly) grounded systems

The Non-directional sensitive ground-fault detection (ANSI 51Ns) serves:

- For ground-fault detection in isolated or resonant-grounded systems
- For detection of high resistance ground faults in effectively (solidly) or low resistance (semi solidly) grounded systems

6.11.2 Structure of the Function

Directional Sensitive Ground Fault Detection

The Directional sensitive ground-fault detection function can be used in protection function groups that make current and voltage zero-sequence systems (3I0 and V0) available. The function is preconfigured at the factory with a V0> stage, a directional 3I0> stage with cos φ or sin φ measurement, and a transient ground-fault stage.

The following stages can be operated simultaneously within the function:

- 2 V0> stages with determination of the faulty phase
- 4 directional 3I0> stages with cos φ or sin φ measurement
- 2 directional transient ground-fault stages
- 4 directional 3I0> stages with φ(V0, 3I0) measurement
- 4 directional Y0> stages with G0 or B0 measurement (admittance method)
- 4 non-directional 3I0> stages
- 2 non-directional Y0> stages

The general functionality works across stages on the function level.

The group indications output logic generates the following group indications of the entire function by the logical OR from the stage selective indications:

- Pickup
- Operate indication

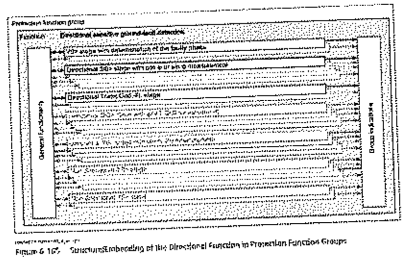

Figure 6-165 Structure/Embedding of the Directional Function in Protection Function Groups

Non-Directional Sensitive Ground-Fault Detection

The Non-directional sensitive ground-fault detection function can be used in protection function groups that only make the zero-sequence system (3I0) available. The function is preconfigured at the factory with a non-directional 3I0> stage.

4 non-directional 3I0> stages and 2 non-directional Y0> stages can be operated simultaneously in the function.

The general functionality works across stages on the function level.

The group indications output logic generates the following group indications of the entire function by the logical OR from the stage-selective indications:

- Pickup
- Operate indication

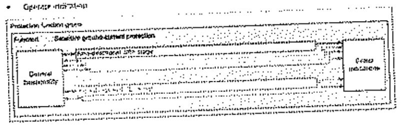

Figure 6-166 Structure/Embedding of the Non-Directional Function in Protection Function Groups

6.11.3 General Functionality

6.11.3.1 Description

Logic

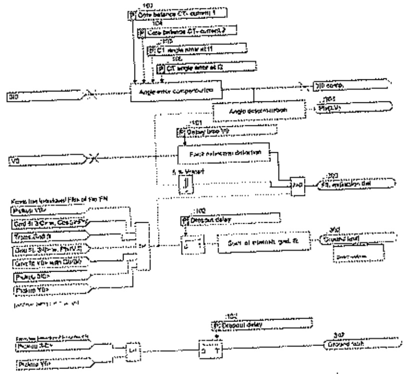

Figure 6-167 Logic Diagram of the Cross-Stage Functionality of the Non-Directional Function

Operational Measured Value φ(I,V)

The function block calculates the angle between I0 and V0 and makes the angle available as function measured value Phi (I, V).

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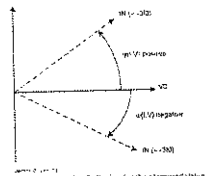

Figure 6-168 Sign Definition for the Measured Value

Fault-Extinction Detection

The extinction of the fault is characterized by the fact that the zero-sequence voltage subsides. Depending on the system conditions and fault characteristics, this process can last several 100 ms. If a continuously falling zero-sequence voltage is detected during the set time Decay time V0, then the fault is considered extinguished. The signal Flt. extinction det. is issued.

Thus, the possibility exists, for example, to block the 3I0> stage with cos φ or sin φ measurement directly after the fault extinction, in order to avoid an overfunction during the subsiding process with a very sensitive setting of the stage.

Angle Error Compensation

The high reactive power factor in the arc-suppression-coil ground system and the unavoidable air gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. Using the characteristic shown in the following figure, the device approaches the angle error of the core balance current transformer with sufficient precision.

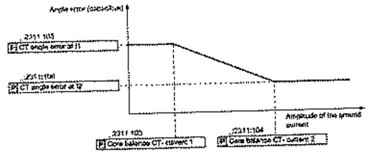

Figure 6-169 Correction of the Transmission Characteristic Curve of a Core Balance Current Transformer

Ground-Fault Indication, Stabilization at Intermittent Ground Fault

The indication (_:302) Ground fault indicates the ground fault and manages the ground-fault log (see Ground-Fault Log, Page 596). The corresponding information of the stages used is accessed for the generation of this indication.

The indication Ground fault contains the direction information, independent of the parameterized working direction of a stage. The indication is thus suited for transfer to a station.

To avoid a flood of indications in case of an intermittent ground fault, a maximum of 20 status changes of this indication is routed per ground fault. An intermittent ground fault must be treated as a ground fault so that the stabilization can take action. This is ensured with the parameter Dropout delay, by the dropout of the indication Ground fault being delayed. If the next ignition of the ground fault takes place during the dropout delay, the indication does not dropout, and the log remains open.

> **NOTE**
> The Ground fault indication in the general stage must be routed to the ground-fault log. If not, you can meet an overflow of the ground-fault log when an intermittent ground fault occurs.

Ground-Fault Log

Ground faults can be recorded in a designated buffer, the ground-fault log. As long as the Operate & flt.rec. blocked parameter is set to yes, no indications routed into the ground-fault log are written in the ground fault log.

The criterion for opening the ground-fault log is the raising of any indication which is routed to the ground-fault log, for example, the indication Ground fault. The criterion for closing is the clearing of all routed indications.

Related Topic

You can find general notes on the ground-fault logs in chapter Indications under 3.1.5.4 Ground Fault Log.

Value Indications

If the following value indications can be calculated, they are written into the log (ground fault log or fault log) at the time of the 1st raising ground-fault indication and the 1st operate indication of any stage.

- 3I0 (value)
- 3I0 active component
- 3I0 reactive component
- V0
- φ (IN, V0)

6.11.3.2 Application and Setting Notes

Indication: Ground fault

To indicate the ground fault and its direction via the protocol, Siemens recommends using the indication (_:302) Ground fault. The indication contains the direction information, independent of the parameterized working direction of a stage. And this indication is also stabilized against a flood of indications in case of an intermittent ground fault.

Parameter: Decay time V0

- Recommended setting value (_:101) Decay time V0 = 0.10 s

With the Decay time V0 parameter, you specify the time slot for the detection of a fault extinction. If V0 continuously falls within this time, fault extinction is detected and the indication Flt. extinction det. is issued.

Siemens recommends using the default setting.

Parameter: Dropout delay

- Recommended setting value (_:102) Dropout delay = 1.00 s

To avoid chattering of the indication Ground fault during an intermittent ground fault and thus a frequent opening and closing of the ground-fault log, the dropout of the indication Ground fault (and thus the closing of the log) can be delayed by the Dropout delay.

Siemens recommends using the default setting.

Using the default setting ensures that no flood of indications arises in case of an intermittent ground fault for the indication Ground fault. The intermittent ground fault is then treated as a ground fault, and the stabilization of the indication Ground fault can thus take action.

Angle Error Compensation of the Core Balance Current Transformer

- Default setting (_:103) Core balance CT- current 1 = 0.050 A
- Default setting (_:104) Core balance CT- current 2 = 1.000 A
- Default setting (_:105) CT angle error at I1 = 0.0°
- Default setting (_:106) CT angle error at I2 = 0.0°

The high reactive power factor in the arc-suppression-coil ground system and the unavoidable air gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. For the burden actually connected, the maximum angle error CT angle error at I1 and the corresponding secondary current Core balance CT- current 1 as well as a further operating point CT angle error at I2/Core balance CT- current 2 are entered, from which point the angle error no longer changes appreciably.

In the isolated or grounded system, angle compensation is not necessary.

6.11.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	General:Decay time V0		0.06 s to 0.20 s	0.10 s
_:102	General:Dropout delay		0.00 s to 60.00 s	1.00 s
_:103	General:Core balance CT- current 1	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:104	General:Core balance CT- current 2	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:105	General:CT angle error at I1		0.0° to 5.0°	0.0°
_:106	General:CT angle error at I2		0.0° to 5.0°	0.0°

6.11.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:302	General:Ground fault	ACD	O
_:303	General:Flt. extinction det.	SPS	O

No.	Information	Data Class (Type)	Type
_:309	General:Pos. measuring window	SPS	O
_:301	General:Phi(I,V)	MV	O

6.11.4 Directional 3I0 Stage with Cos φ or Sin φ Measurement

6.11.4.1 Description

Logic

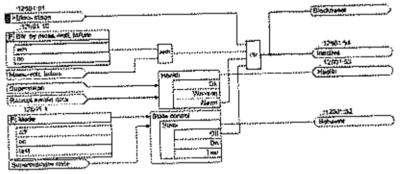

Figure 6-170 Logic Diagram of the Stage Control

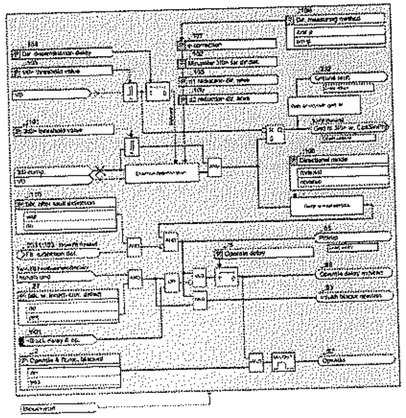

Figure 6-171 Logic Diagram of the Directional 3I0 Stage with Cos φ or Sin φ Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 I_N, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the setting of the parameter Connection type of the measuring point I-3ph as well as the current terminal block used, the following different linearity and settings ranges result in addition to the usual applications:

Setting Value Connection Type of the Measuring Point I-3ph	3I0	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [1]
3-phase + IN separate [2]	Measured	3 x protection, 1 x sensitive	0.001 A to 35.000 A
3-phase + IN		4 x protection	0.030 A to 35.000 A
		4 x measurement	0.001 A to 1.600 A
3-phase	Calculated	4 x protection	0.030 A to 35.000 A
		3 x protection, 1 x sensitive	0.030 A to 35.000 A
		4 x measurement	0.001 A to 1.600 A

With the use of the function within a 1-phase function group and therefore at a 1-phase measuring point I-1ph, the following different linearity and settings ranges result:

Measuring Point I-1ph	3I0	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [1]
	Measured	Sensitive	0.001 A to 1.600 A
		Protection	0.030 A to 35.000 A

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (leakage) current.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 exceeds the threshold value 3I0> threshold value and the absolute value of the zero-sequence voltage V0 exceeds the threshold value V0> threshold value, the stage recognizes the ground fault. The direction determination (see the next paragraph) is started when the V0 threshold value is exceeded. The direction result is indicated via the Ground fault signal (in the general function block). If the direction result equals the parameterized direction (parameter Directional mode), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands. The result from the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its threshold value.

The following figure shows an example of the direction determination in the complex phasor diagram for the cos φ direction measurement method with a correction value of the direction straight lines from 0 (parameter φ correction). The example is suitable for the determination of the ground fault direction in an arc-suppression-coil ground system where the variable 3I0 · cos φ is decisive for the direction determination.

[1] These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.

[2] Typical application

[illegible] These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.

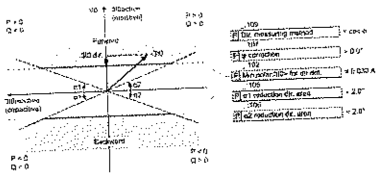

Figure 6-172 Direction-Characteristic Curve with Cos φ Measurement

The zero-sequence voltage V0 is basically the reference value for the real axis. The axis of symmetry of the direction characteristic curve coincides with the 3I0active axis for this example. For the direction determination, basically the portion of the current vertical to the set direction-characteristic curve (= axis of symmetry) is decisive (3I0 dir.). In this example, this is the active portion 3I0active of the current 3I0. The current 3I0dir. (here = 3I0active) is calculated and compared with the setting value Min.polar.3I0> for dir.det.. If the current 3I0 dir. exceeds the positive setting value, the direction is forward. If the current 3I0 dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the α1 reduction dir. area and α2 reduction dir. area parameters, you can limit the forward and backward ranges as shown in the figure. With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle (φ correction parameter) in a range of ±45°. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a rotation of +45°.

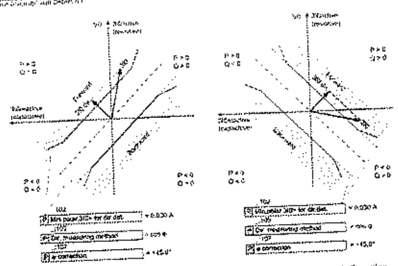

Figure 6-173 Turning the Direction-Characteristic Curves with Cos φ Measurement with Angle Correction

If you set the Dir. measuring method parameter to sin φ and the φ correction parameter to 0, the symmetry axis of the direction-characteristic curve coincides with the 3I0active axis and the V0 axis. Since the portion of the current vertical to the direction-characteristic curve (= axis of symmetry) is decisive (3I0dir.), here, the current 3I0react is included in the direction determination. If the current 3I0dir. (here, -3I0react) exceeds the negative setting value Min.polar.3I0> for dir.det., the direction is forward. If the current 3I0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground-fault direction in isolated systems.

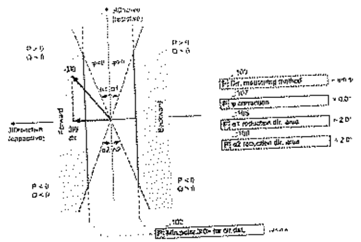

Figure 6-174 Direction-Characteristic Curve with Sin φ Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pick up of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Voltage transformer circuit breaker, which links in the tripping of the voltage-transformer circuit breaker.

The Blk. by meas.-volt. failure parameter can be set so that Measuring-voltage failure detection blocks the stage or does not block it.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the Blk. after fault extinction parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is created.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.11.4.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and enabled.
- The binary input signal >Open of the function block Voltage transformer circuit breaker is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting
no	The protection stage is not blocked.

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value (_:27) Blk. w. inrush curr. detect. = no

With the Blk. w. inrush curr. detect. parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by an enabling procedure.

Parameter: Blk. after fault extinction

- Recommended setting value (_:110) Blk. after fault extinction = yes

If the Blk. after fault extinction parameter is set to yes, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: Directional mode

- Default setting (_:108) Directional mode = forward

When a fault is detected, the selection of the parameter Directional mode defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: Dir. measuring method, φ correction, Min.polar.3I0> for dir.det., 3I0> threshold value

- Default setting (_:109) Dir. measuring method = cos φ
- Default setting (_:107) φ correction = 0.0°
- Default setting (_:102) Min.polar.3I0> for dir.det. = 0.030 A
- Default setting (_:101) 3I0> threshold value = 0.030 A

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral point treatment of the system.

Note that, for the direction determination, basically only a portion of the current vertical to the set direction-characteristic curve (3I0dir.) is decisive, refer to 6.11.4.1 Description. This portion of the current is compared to the threshold value Min.polar.3I0> for dir.det.. In contrast, the absolute value of the current 3I0 is compared with the 3I0> threshold value parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt leakage current 3I0 · cos φ of the arc-suppression coil is decisive for the direction determination. To evaluate the watt leakage current, set the parameters as follows: • Dir. measuring method = cos φ • φ correction = 0.0° The direction determination for a ground fault is made more difficult in that a much larger capacitive or inductive reactive current is superimposed on the small watt leakage current. Therefore, depending on the system configuration and the fault situation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the Min.polar.3I0> for dir.det. parameter, the rule of thumb is: Set the pickup value only to half of the expected measuring current as only the watt leakage current can be put into use. The 3I0> threshold value parameter can also be set to half of the expected measuring current, whereby here the entire zero-sequence current can be put to use.
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • Dir. measuring method = sin φ • φ correction = 0.0° In an isolated system, the capacitive ground-fault currents of the entire electrically connected system flow through the measuring point in case of a ground fault. The ground current of the faulty feeder is compensated in the measuring point. As the pickup value of the Min.polar.3I0> for dir.det. and 3I0> threshold value parameters, select about half of this capacitive ground fault current flowing via the measuring point.

System Type/ Neutral-Point Treatment	Description
Resistance Grounded	In the resistance grounded system, the ohmic-inductive ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • Dir. measuring method = cos φ • φ correction = -45.0° Set the Min.polar.3I0> for dir.det. and 3I0> threshold value parameters to a value below the minimum ground fault current to be expected.

Parameter: α1 reduction dir. area, α2 reduction dir. area

- Recommended setting value (_:105) α1 reduction dir. area = 2°
- Recommended setting value (_:106) α2 reduction dir. area = 2°

With the α1 reduction dir. area and α2 reduction dir. area parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: V0> threshold value

- Default setting (_:103) V0> threshold value = 30.000 V

The V0> threshold value parameter allows you to set the zero-sequence voltage sensitivity of the stage. Set the threshold value smaller than the minimum absolute value of the zero-sequence voltage V0 that must still be detected.

Parameter: Dir. determination delay

- Default setting (_:104) Dir. determination delay = 0.00 s

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 2.0 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.11.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> cos/sinφ#				
_:1	3I0> cos/sinφ#:Mode		• off • on • test	off
_:2	3I0> cos/sinφ#:Operate & flt.rec. blocked		• no • yes	no
_:10	3I0> cos/sinφ#:Blk. by meas.-volt. failure		• no • yes	yes
_:27	3I0> cos/sinφ#:Blk. w. inrush curr. detect.		• no • yes	no

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Addr.	Parameter	C	Setting Options	Default Setting
_:110	3I0> cos/sinφ:Blk. after fault extinction		• no • yes	yes
_:109	3I0> cos/sinφ:Directional mode		• forward • reverse	forward
_:109	3I0> cos/sinφ:Dir. measuring method		• cos φ • sin φ	cos φ
_:102	3I0> cos/sinφ:φ correction		-45 ° to 45 °	0°
_:102	3I0> cos/sinφ:Min. polar 3I0> for dir. det.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.150 A
_:105	3I0> cos/sinφ:α1 reduction dir. area		1 ° to 15 °	2°
_:106	3I0> cos/sinφ:α2 reduction dir. area		1 ° to 15 °	2°
_:101	3I0> cos/sinφ:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:103	3I0> cos/sinφ:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	3I0> cos/sinφ:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> cos/sinφ:Operate delay		0.00 s to 60.00 s	2.00 s

6.11.4.4 Information List

No.	Information	Data Class (Type)	Type
3I0> cos/sinφ #			
_:81	3I0> cos/sinφ:>Block stage	SPS	I
_:501	3I0> cos/sinφ:>Block delay & op.	SPS	I
_:54	3I0> cos/sinφ:Inactive	SPS	O
_:52	3I0> cos/sinφ:Behavior	ENS	O
_:53	3I0> cos/sinφ:Health	ENS	O
_:60	3I0> cos/sinφ:Inrush blocks operate	ACT	O
_:55	3I0> cos/sinφ:Pickup	ACD	O
_:56	3I0> cos/sinφ:Operate delay expired	ACT	O
_:57	3I0> cos/sinφ:Operate	ACT	O
_:302	3I0> cos/sinφ:Ground fault	ACD	O

6.11.5 Directional Transient Ground-Fault Stage

6.11.5.1 Description

Overview

Ground faults occurring in arc-suppression-coil-grounded systems quite often extinguish a short time after the ignition, mostly within a few milliseconds. Such transient occurrences are called transient ground faults. In order to detect the ground-fault direction, based on these transient occurrences, a special method of measurement is required that can also capture high frequencies. Conventional methods based on phasor calculations are not suitable, even for ground faults lasting for a short time, mostly, a high-frequency charging process occurs in healthy phases. The transient charging process is evaluated by the transient ground-fault method of measurement to determine the ground fault direction. An integrating method of measurement ensures a high degree of sensitivity and a positive stability against parasitic signals in the zero-sequence system.

Since permanent ground faults also start with the transient charging process of faultless wires, these errors will be detected as well.

This process is most suitable for the use in closed loops or meshed systems. Operational, circulating zero-sequence currents are eliminated and therefore, cannot affect the directional result.

Stage-Control Logic

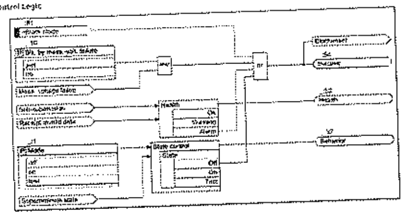

Figure 6-175 Logic Diagram of the Stage Control

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal >Open of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker

The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or not.

Logic of the Transient Ground-Fault Functionality

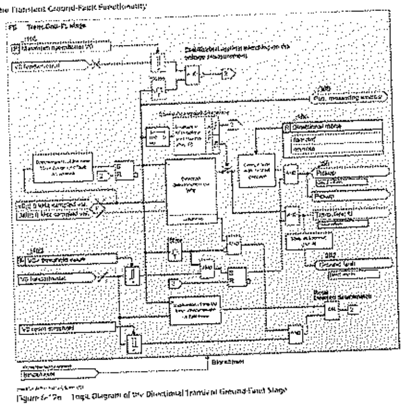

Figure 6-176 Logic Diagram of the Directional Transient Ground-Fault Stage

Measured Values, Method of Measurement

The zero-sequence values of zero-sequence voltage and zero-sequence current are measured directly or calculated from the phase variables. When measuring directly, the following is detected:

- Zero-sequence voltage on the broken-delta winding
- Zero-sequence current via Holmgreen connection or via core balance current transformer

The voltage measured on the broken-delta winding will be converted to zero-sequence voltage V_0.

The instantaneous values of the zero-sequence voltage V0(t) that are sampled at a high frequency (8 kHz) serve to determine the point in time of the ground fault occurrence T0.

The instantaneous values of the zero-sequence voltage V0(t) and the ground current 3I0(t), which are sampled at a high frequency (8 kHz), are the basis for direction determination.

The fundamental-component values of the zero-sequence voltage V0 serve to release the directional result and the pickup as well as a criterion for the stabilization against switching operations.

The positive-sequence system (if it exists as a measured value) serves as an additional criterion for the stabilization against switching operations.

The fundamental-component values V0 and 3I0 will be used in the optional trip logic.

Operational, meaning circulating zero-sequence currents, can occur in closed loops or meshed systems. This type of zero-sequence current is also present in case of a failure and can falsify the directional result. Therefore, an operational zero-sequence current is eliminated.

Determining the Time of the Ground-Fault Ignition

The algorithm uses the evaluation of the instantaneous values of the zero-sequence voltage to verify continuously if a ground fault occurred. This takes place regardless of whether the set threshold value for V0 is exceeded. If a ground fault occurred, the measuring window for determining the direction is positioned and the direction determination is performed. The position of the measuring window is logged via the indication Pos. measuring window (in FB General). The precise identification of the time T0 at which the ground fault occurred is decisive for the correct direction determination.

Determination of Direction, Method of Measurement

The active energy of the zero-sequence system is calculated for the direction determination. Once the ground fault occurrence has been detected, the active energy will be calculated across approximately 1 cycle frequency. If the active energy of the zero-sequence system is negative, a forward fault is present; otherwise it is a backward fault.

Direction Result Message, Pickup

Determining the time of the ground-fault ignition and the direction is always done with maximum sensitivity. With the parameter V0> threshold value, you define the sensitivity for the indication of the direction and the pickup of the stage.

If the fundamental-component value of the zero-sequence voltage V0 exceeds the associated threshold value (V0> threshold value parameter) within 100 ms after detecting the ground fault ignition, the direction result will be reported. In this way, high-impedance ground faults are also reported in which the zero-sequence system values rise only slowly, and, for this reason, the occurrence of the ground fault is detected noticeably earlier than the exceedance of the parameterized threshold value.

The direction result will be reported to the function via the (_:302) Ground fault of the function block **General Information**. This indication is reported irrespective of the parameterized direction of the function. If the determined direction corresponds with the parameterized direction (parameter Directional mode), a pickup occurs.

Reset of the Algorithm

To allow a new directional measurement, the algorithm needs to be reset. The normal reset takes place when the fundamental component of the zero-sequence voltage V0 drops below the V0 reset threshold. This reset threshold is a small device-internal V0 threshold. It is also depending on an operational V0 and is thus a dynamic threshold. The threshold value is 3.0 V secondary without dynamic influence.

Stabilization against Switching Operations

Switching operations in the system to be protected can cause transient signals in the zero-sequence system. The stage is stabilized against possible malfunction due to switching operations.

The following mechanisms are applied:

- For reporting the direction result, the fundamental-component value of the zero-sequence voltage must exceed the V0> threshold value in a time slot of 100 ms after the ground fault extinction. This effectively suppresses wrong indications as a result of switching operations.
- The fundamental-component value of the zero-sequence voltage V0 is not influenced by switching operations and is thus a good criterion for distinguishing the ground fault from a switching procedure. The condition that the fundamental-component value must exceed the V0> threshold value for reporting the direction result effectively suppresses switching operations.
  For rare cases in which high zero-sequence voltages occur over longer time ranges after switching off the feeder or line, a criterion on the basis of the positive-sequence system current is now effective. This criterion compares the positive-sequence system current before and after the transient event and thus detects a disconnection. In case of disconnection, the direction result is not reported.
  Through stabilization mechanisms, the direction result is reported 100 ms after the ground-fault ignition, thus a pickup occurs with a 100-ms delay.
  If the stage is used in a 1-phase function group, the additional criterion via the positive-sequence system current is not effective.
- The function detects transient occurrences in the zero-sequence voltage. In systems with operational zero-sequence voltage, if the measuring voltage is switched on, the function can internally be started. If the fundamental-component value of the zero-sequence voltage does not exceed the threshold of the Maximum operational V0 parameter in a time slot of 100 ms after the function start, the function is reset internally.

Trip Logic

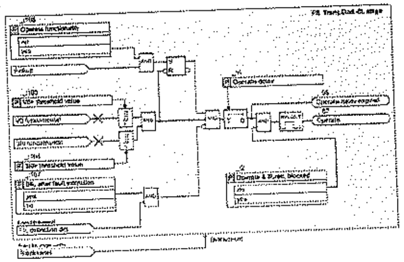

Figure 6-177 Trip Logic Diagram

In many applications, the transient ground-fault stage is used only to indicate the direction. In this case, the trip logic is not required and remains disabled. However, this stage can also be used to disable a permanent ground fault. For this, you enable the optional trip logic with the Operate functionality parameter. If the fundamental-component values V0 and 3I0 exceed the set threshold values, the operate delay (_:Operate delay parameter) starts with the pickup. In order to start the operate delay, the threshold values must be

exceeded during the time delay. The expiry of the operate delay will be indicated. If the Operate & flt.rec. blocked setting is set to no, the pickup indication is sent.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value cycle of the zero-sequence voltage, the fault extinction of the ground fault can be detected faster than via the dropout of the V0 fundamental-component value under the pickup value. The fast detection of the fault extinction (see function block **General Information**) blocks the tripping time delay. When using the parameter Blk. after fault extinction, this accelerates blocking mechanism can be enabled or disabled.

6.11.5.2 Application and Setting Notes

Parameter: Operate functionality

- Default setting (_:109) Operate functionality = no

If the transient ground-fault stage is used only to indicate the direction, the optional trip logic is not required and remains disabled. If the transient ground-fault stage is used to disable permanent faults as well, this optional trip logic is enabled. Pickup of the stage will initiate the tripping delay.

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal >Open of the function block Voltage transformer circuit breaker is linked with the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Blk. after fault extinction

- Recommended setting value (_:107) Blk. after fault extinction = yes

If the Blk. after fault extinction parameter is set to yes, the tripping delay is reset after the detection of the fault extinction. Therefore, if the tripping delay is set for a short time, the possibility of an overfunction is avoided. The means for an overfunction is a slower attenuation in the zero-sequence system following the fault extinction. Siemens recommends keeping this default setting if the stage is used for tripping. If you are using the stage only for reporting or for detecting intermittent faults, you have to disable the blocking.

Parameter: Directional mode

- Default setting (_:106) Directional mode = forward

When a fault is detected, the selection of the parameter Directional mode defines whether the pickup of the stage occurs in forward or backward direction.

ВЯРНО С ОРИГИНАЛА

Parameter: V0> threshold value

- Default setting (_:105) V0> threshold value = 15.000 V

With the parameter V0> threshold value, you define the sensitivity for the indication of the direction and the pickup of the stage.

Note that the sensitivity of the direction determination itself is not thereby changed. The direction determination always works with maximum sensitivity.

Except high-resistive ground faults be of interest as well, very sensitive settings are possible, for example, V0> threshold value = 5 V secondary.

Parameter: Maximum operational V0

- Recommended setting value (_:105) Maximum operational V0 = 3.000 V

The setting of the Maximum operational V0 parameter is in conjunction with the stabilization against switching operations.

The setting is made with reference to the zero-sequence voltage V0 according to its definition.

Network Structure	Description
Radial system	In the primary system, no operational zero-sequence voltages are present. A measured zero-sequence voltage results from tolerances within the voltage measurement, for example, from the voltage transformers. Siemens recommends using the default value of 3.000 V.
Ring network, meshed network	Operational zero-sequence voltages can occur in such networks. The secondary operational zero-sequence voltages can be determined by reading the residual voltage $V_{N,sec}$ or the zero-sequence voltage $V_{0,sec}$ under the symmetrical components from the device or via DIGSI. In case you read the secondary residual voltage $V_{N,sec}$, you convert it to $V_{0,sec}$ with the Matching ratio Vph / VN parameter. You can find more information in chapter 6.2.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph). If $V_{0,sec}$ is greater than 2.5 V, the value of Maximum operational V0 shall be increased to $V_{0,sec} \cdot 1.2$ Example: $V_{N,sec}$ = 5.000 V Matching ratio Vph / VN = √3 $V_{0,sec}$ = 5.000 V · 1/√3 = 2.887 V Maximum operational V0 = 2.887 V · 1.2 = 3.464 V In most cases, the operational zero-sequence voltages will be smaller than 2.500 V. Siemens recommends using the default value of 3.000 V

Parameter: 3I0> threshold value

- Default setting (_:104) 3I0> threshold value = 0.030 A

The setting is significant only for optional trip logic for switching off permanent ground faults. Select the setting such that the static ground-fault current exceeds the threshold value.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 0.50 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

The setting of the Operate delay depends on the specific application. Ensure that the pickup is delayed by 100 ms with regard to the time of the ground-fault ignition.

6.11.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trans.Gnd.flt#				
_:1	Trans.Gnd.flt#:Mode		• off • on • test	off
_:2	Trans.Gnd.flt#:Operate & flt.rec. blocked		• no • yes	no
_:110	Trans.Gnd.flt#:Blk. by meas.-volt. failure		• no • yes	yes
_:107	Trans.Gnd.flt#:Blk. after fault extinction		• no • yes	yes
_:108	Trans.Gnd.flt#:Operate functionality		• no • yes	no
_:106	Trans.Gnd.flt#:Directional mode		• forward • reverse	forward
_:103	Trans.Gnd.flt#:V0> threshold value		0.300 V to 200.000 V	75.981 V
_:104	Trans.Gnd.flt#:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:6	Trans.Gnd.flt#:Operate delay		0.00 s to 60.00 s	0.50 s
_:105	Trans.Gnd.flt#:Maximum operational V0		0.300 V to 200.000 V	3.000 V

6.11.5.4 Information List

No.	Information	Data Class (Type)	Type
Trans.Gnd.flt#			
_:81	Trans.Gnd.flt#:>Block stage	SPS	I
_:54	Trans.Gnd.flt#:Inactive	SPS	O
_:52	Trans.Gnd.flt#:Behavior	ENS	O
_:53	Trans.Gnd.flt#:Health	ENS	O
_:55	Trans.Gnd.flt#:Pickup	ACD	O
_:56	Trans.Gnd.flt#:Operate delay expired	ACT	O
_:57	Trans.Gnd.flt#:Operate	ACT	O
_:302	Trans.Gnd.flt#:Ground fault	ACD	O

6.11.6 Usage Information for Detection of Intermittent Ground Faults

The stage type 3I0> with cos φ or sin φ measurement is suited for directional detection of intermittent ground faults. Many years of field experience and field tests have shown that the direction determination of this stage type reliably determines the direction of the current peaks. Between the current peaks, the direction is detected as unknown. To generate a tripping or an alarm, you can analyze the individual pickups of a stage (each directional pickup corresponds to a current peak) in a time-based way or count them via an additional user logic (CFC chart).

You can also ensure the result in the user-logic via a 2nd directional stage that works in the backward direction, as well as a V0 stage.

You can operate a 2nd directional stage in parallel for the detection of permanent ground faults.

In the following, certain settings are explained that are necessary for this application (detection of intermittent ground faults):

- Parameter: (_:102) Dropout delay
  The function must hold the intermittent process over ground fault. For this, it is necessary that the indication Ground fault does not drop out between 2 consecutive current peaks. This is ensured via the Dropout delay parameter (FB General). A dropout delay of 1 s is a feasible value.
- Parameter: (_:104) Dir. determination delay
  You must set the delay of the direction determination to 0 s, so that the direction of the current peaks can be determined.
- Parameter: (_:105) α1 reduction dir. area and (_:106) α2 reduction dir. area
  The current peaks show a clear active component. With these parameters, you can limit the direction characteristic and ensure a reliable direction result.
  Siemens recommends setting both parameters to 10°.
- Parameter: (_:110) Blk. after fault extinction
  To make possible a continuous and immediate detection of the current peaks, you must switch off the blocking after fault suppression.

For further parameters, there are no particular considerations with regard to an intermittent ground fault. You can set these as for the detection of permanent ground faults.

6.11.7 Directional 3I0 Stage with φ(V0,3I0) Measurement

6.11.7.1 Description

Logic

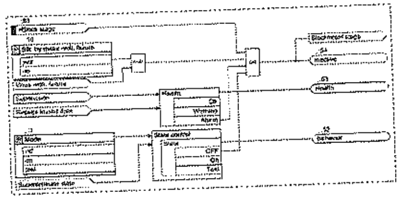

Figure 6-178 Logic Diagram of the Stage Control

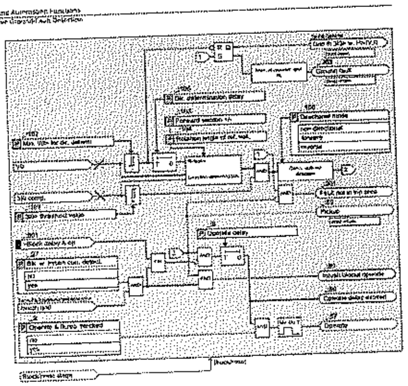

Figure 6-179 Logic Diagram of the Directional 3I0 Stage with φ(V0,3I0) Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

This method of measurement processes the sampled current values and filters out the fundamental component numerically.

Depending upon the settings of the Connection type and Measuring point I-3ph parameters, as well as the current terminal block used, different linearity and setting ranges result, refer for this to chapter 6.11.4.1 Description, Ground-Fault Detection, Pickup.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 vector exceeds the threshold value 3I0> threshold value and the absolute value of the zero-sequence voltage V0 vector exceeds the threshold value Min. V0> for dir. determ., the stage detects the ground fault. The direction determination (see in the following paragraph) is started when the zero-sequence voltage exceeds the threshold. The result from the direction determination is only valid if the absolute value of the ground current 3I0 vector has also exceeded its threshold value. The direction result is indicated via the Ground fault signal (in the General function block).

As long as the direction result equals the parameterized direction (parameter Directional mode), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands.

The direction is determined via the determination of the phase angle between the angle error compensated ground current 3I0comp. and the rotated zero-sequence voltage V0, indicated in the following as reference voltage $V_{ref,rot}$. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (Rotation angle of ref. volt. parameter). This moves the vector of the rotated reference voltage close to the vector ground current -3I0comp. Consequently, the result of direction determination is as reliable as possible.

The rotated reference voltage $V_{ref,rot}$ and the Forward section +/- parameter define the forward and reverse area. The forward area results as range ± Δφ around the rotated reference voltage $V_{ref,rot}$. The value ± Δφ is set with the Forward section +/- parameter. The remaining area besides the forward area is the reverse area. Between the forward and reverse area, a hysteresis is defined, refer to Figure 6-180.

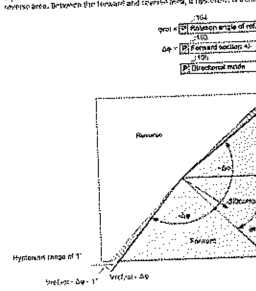

Figure 6-180 Directional Characteristic in Forward Mode

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >open of the function block Voltage transformer circuit breaker, which links in the tripping of the voltage-transformer circuit breaker.

The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or not.

Blocking the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.11.7.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and enabled.
- The binary input signal >open of the function block Voltage transformer circuit breaker is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value (_:27) Blk. w. inrush curr. detect. = no

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With the Blk. w. inrush curr. detect. parameter you specify whether the operate is blocked during the detection of an inrush current.

Symmetric components including the blocking. The fundamental component of the zero-sequence voltage is a release criterion for the ground fault and remains unaffected by an inrushing condition.

Parameter: Directional mode

- Default setting (_:106) Directional mode = forward

When a fault is detected, the selection of the parameter Directional mode defines whether the pickup of the stage occurs in forward or reverse direction.

When the parameter Directional mode is set as non-directional, the direction determination is not considered. The pickup condition depends only on the absolute values 3I0 and V0 and the respective thresholds.

Parameter: Rotation angle of ref. volt., Forward section +/-

- Default setting (_:104) Rotation angle of ref. volt. = -45°
- Default setting (_:103) Forward section +/- = 88°

With the Rotation angle of ref. volt. and Forward section +/- parameters, you set the direction characteristic, that is, the areas of forward and reverse. With this, you set the direction characteristic according to the system conditions and the neutral-point treatment.

Typical settings for the Rotation angle of ref. volt parameter are:

- Arc-suppression-coil ground system: 0°
- Isolated system: -45°
- Grounded system: -45°

The Forward section +/- parameter can normally be left at its default setting. A reduction of the forward area by a few degrees is practical, for example in an arc-suppression-coil-ground system with long cable feeders, that generate high capacitive fault currents.

Parameter: Min. V0> for dir. determ.

- Default setting (_:107) Min. V0> for dir. determ. = 2.000 V

With the Min. V0> for dir. determ. parameter, you determine the minimum voltage V0 necessary for the release of the direction determination that must be attained within the time delay Dir. determination delay.

Parameter: 3I0> threshold value

- Default setting (_:101) 3I0> threshold value = 0.050 A

The 3I0> threshold value parameter allows you to set the ground-current sensitivity of the stage. Set the threshold value lower than the minimum absolute value of the ground-fault current 3I0 that must still be detected.

Parameter: Dir. determination delay

- Default setting (_:105) Dir. determination delay = 0.10 s

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 0.50 s

The parameter value Operate delay determines the direction time within which the pickup conditions must be present. An operate indication is only issued when the time is exceeded.

6.11.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> φ(V,I) #				
_:1	3I0> φ(V,I) #:Mode		• off • on • test	off
_:2	3I0> φ(V,I) #:Operate & flt.rec. blocked		• no • yes	no
_:[illegible]	3I0> φ(V,I) #:Blk. by meas.-volt. failure		• no • yes	yes
_:[illegible]	3I0> φ(V,I) #:Blk. w. inrush curr. detect.		• no • yes	no
_:106	3I0> φ(V,I) #:Directional mode		• non-directional • forward • reverse	forward
_:104	3I0> φ(V,I) #:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °
_:103	3I0> φ(V,I) #:Forward section +/-		0 ° to 180 °	88 °
_:107	3I0> φ(V,I) #:Min. V0> for dir. determ.		0.300 V to 200.000 V	2.000 V
_:101	3I0> φ(V,I) #:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:105	3I0> φ(V,I) #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> φ(V,I) #:Operate delay		0.00 s to 60.00 s	0.50 s

6.11.7.4 Information List

No.	Information	Data Class (Type)	Type
3I0> φ(V,I) #			
_:81	3I0> φ(V,I) #:>Block stage	SPS	I
_:501	3I0> φ(V,I) #:>Block. delay & op.	SPS	I
_:54	3I0> φ(V,I) #:Inactive	SPS	O
_:52	3I0> φ(V,I) #:Behavior	ENS	O
_:53	3I0> φ(V,I) #:Health	ENS	O
_:301	3I0> φ(V,I) #:Fault not in trip area	SPS	O
_:300	3I0> φ(V,I) #:Inrush blocks operate	ACT	O
_:303	3I0> φ(V,I) #:Ground fault	ACD	O
_:55	3I0> φ(V,I) #:Pickup	ACD	O
_:56	3I0> φ(V,I) #:Operate delay expired	ACT	O
_:57	3I0> φ(V,I) #:Operate	ACT	O

6.11.8 Directional Y0 Stage with G0 or B0 Measurement

6.11.8.1 Description

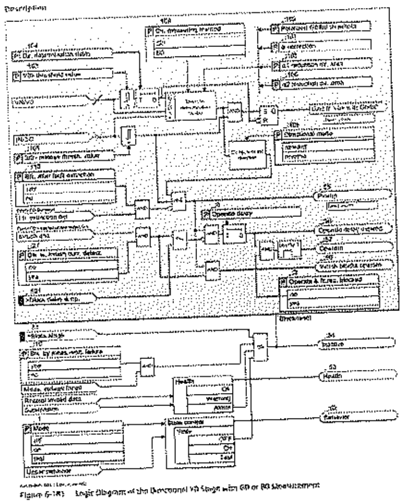

Figure 6-181 Logic Diagram of the Directional Y0 Stage with G0 or B0 Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the definition equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, G0, B0, Method of Measurement

The function usually evaluates the ground current 3I0 sensitively measured via a core balance current transformer, this current being converted with the voltage V0 into the admittance Y0 = G0 + jB0. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically. The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (leakage) current.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 exceeds the threshold value 3I0> release thresh. value and the absolute value of the zero-sequence voltage V0 exceeds the threshold value V0> threshold value, the stage recognizes the ground fault. The calculation of G0 or B0 is started with exceeding the threshold values and then, the direction determination (see the following) is performed. The direction result is indicated via the Ground fault signal (in the General function block). If the direction result equals the parameterized direction (parameter Directional mode), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands. The result from the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its release threshold value. The following figure shows an example of the direction determination in the complex phasor diagram for the G0 direction measurement method with a correction value of the direction straight line from 0 (Parameter φ correction). The example is suitable for the determination of the ground fault direction in an arc-suppression-coil-ground system where the value G0 is decisive for the direction determination.

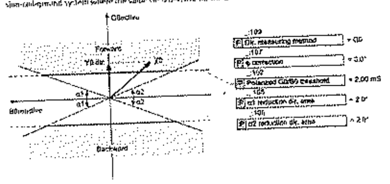

Figure 6-182 Direction-Characteristic Curve for the G0 Measurement

The zero-sequence voltage V0 is normally the reference value for the real axis and is identical to the G0 axis. The axis of symmetry of the direction-characteristic curve coincides with the B0 (reactive) axis for the example. For the direction determination, the component of the admittance perpendicular to the set direction-characteristic curve (= axis of symmetry) is decisive G0dir (-Y0dir). In this example, this is the active component G0 of the admittance Y0. The conductance G0dir (here = G0 active) is calculated and

compared with the setting value Polarized G0/B0 threshold. If the conductance G0dir. exceeds the positive setting value, the direction is forward. If the conductance G0dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the α1 reduction dir. area and α2 reduction dir. area parameters, you can limit the forward and backward ranges as shown in Figure 6-182. With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle (φ correction parameter) in a range of ±45°. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a turn of +45° (see following figure).

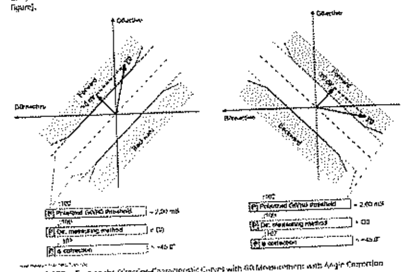

Figure 6-183 Turning the Direction-Characteristic Curve with G0 Measurement with Angle Correction

If you set the Dir. measuring method parameter to B0 and the φ correction parameter to 0, the axis of symmetry of the direction-characteristic curve coincides with the G0 and V0 axes. Since the component of the admittance Y0 perpendicular to the direction-characteristic curve (= axis of symmetry) is direction B0dir. (= B0dir.), here, the susceptance B0 (reactive) is used in the direction determination. If the susceptance B0dir. (B0reactive) exceeds the negative setting value Polarized G0/B0 threshold, the direction is forward. If the susceptance B0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground-fault direction in isolated systems.

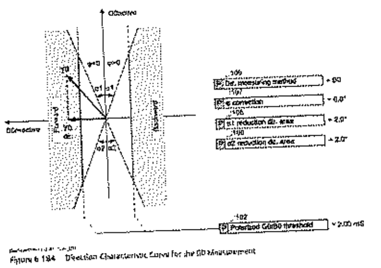

Figure 6-184 Direction Characteristic Curve for the B0 Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Voltage-transformer circuit breaker, which links in the tripping of the voltage-transformer circuit breaker

The Blk. by meas.-volt. failure parameter can be set so that Measuring-voltage failure detection blocks the stage or does not block it.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the first detection of the fault extinction. With this, the pickups are avoided due to the decay processes in the zero-sequence system after the fault extinction. With the Blk. after fault extinction parameter, you enable or disable the accelerated detection of the fault extinction.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

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Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

With the Blk. w. inrush curr. detect. parameter, you can define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.11.8.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and enabled.
- The binary input signal >Open of the function block Voltage transformer circuit breaker is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value (_:27) Blk. w. inrush curr. detect. = no

With the Blk. w. inrush curr. detect. parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains untouched by an enabling procedure.

Parameter: Blk. after fault extinction

- Recommended setting value (_:110) Blk. after fault extinction = yes

If the Blk. after fault extinction parameter is set to yes, the pickup is blocked after extinction of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: Directional mode

- Default setting (_:108) Directional mode = forward

When a fault is detected, the selection of the parameter Directional mode defines whether the pickup of the stage operates in forward or backward direction.

Parameter: Dir. measuring method, φ correction, Polarized G0/B0 threshold, 3I0> release thresh. value

- Default setting (_:109) Dir. measuring method = G0
- Default setting (_:107) φ correction = 0.0°
- Default setting (_:102) Polarized G0/B0 threshold = 2.00 mS
- Default setting (_:101) 3I0> release thresh. value = 0.002 A

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral-point treatment of the system.

Note that, for the direction determination, basically only the component of the admittance perpendicular to the set direction-characteristic curve is decisive, see chapter 6.11.8.1 Description. This admittance component is compared to the threshold value Polarized G0/B0 threshold. In contrast, the absolute value of the current 3I0 is compared with the 3I0> release thresh. value parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt leakage current 3I0 · cos φ of the arc suppression coil is decisive for the direction determination. To evaluate the watt leakage current, set the parameters as follows: • Dir. measuring method = G0 • φ correction = 0.0° The direction determination for a ground fault is made more difficult in that a much larger reactive current of capacitive or inductive character is superimposed on the small watt leakage current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground-fault current. This requires extremely high accuracy, particularly regarding the phase angle measurement of all the instrument transformers. Furthermore, the device must not be set to extremely sensitive. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the Polarized G0/B0 threshold parameter, the following formula applies: $G0 > k_s \cdot \frac{I_{active}}{\sqrt{3}V_{rated}} + \frac{I_{min}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) I_{active}: Active component of the ground-fault current (watt leakage current) of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{min}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) VO>: Pickup threshold of the residual voltage = $0.1\sqrt{3}V_{rated}$ If a parallel resistor Rp is used on the arc-suppression coil, the threshold value G0 must also be smaller than: $G0 < \frac{1}{k_s} \cdot \frac{I_{Rp}}{\sqrt{3}V_{rated}}$ where: k_s: Safety margin ≥ 1.5 I_{Rp}: Secondary rated current of the parallel resistor V_{rated}: Secondary rated voltage in the healthy case The 3I0> release thresh. value parameter can be set to half of the expected measuring current and here, the entire zero-sequence current can be put to use.

System Type/ Neutral-Point Treatment	Description
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • Dir. measuring method = B0 • φ correction = 0.0° In isolated systems, a ground fault allows the capacitive ground-fault currents of the entire electrically connected system, except for the ground current in the faulty cable itself, to flow through the measuring point as the latter flows directly away from the fault location (that is, not via the measuring point). The following formula can be used to determine the pickup value of the Polarized G0/B0 threshold parameter. $B0 > \frac{I_{min}}{V0>}$ where: I_{min}: Ground current in the healthy case VO>: Pickup threshold of the residual voltage = $0.02\sqrt{3}V_{rated}$ In healthy operation, B0 ≈ 0 For the 3I0> release thresh. value parameter, select around half of this capacitive ground-fault current flowing via the measuring point.
Resistance-Grounded	In the resistance-grounded system, the ohmic (effective) ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • Dir. measuring method = G0 • φ correction = -45.0° For the setting of the Polarized G0/B0 threshold parameter, the rule of thumb is: Set the pickup value according to the following formula where only the active ground-fault current can be put into use. $G0 > k_s \cdot \frac{I_{active}}{\sqrt{3}V_{rated}} + \frac{I_{min}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) I_{active}: Active component of the ground-fault current of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{min}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) VO>: Pickup threshold of the residual voltage = $0.02\sqrt{3}V_{rated}$ The 3I0> release thresh. value parameter must be set to a value below the minimum expected ground-fault current.

Parameter: α1 reduction dir. area, α2 reduction dir. area

- Recommended setting value (_:105) α1 reduction dir. area = 2°
- Recommended setting value (_:106) α2 reduction dir. area = 2°

With the α1 reduction dir. area and α2 reduction dir. area parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: V0> threshold value

- Default setting (_:103) V0> threshold value = 30.000 V

The V0> threshold value parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: Dir. determination delay

- Default setting (_:104) Dir. determination delay = 0.10 s

The start of the ground fault normally indicates a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed for this reason from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 2.0 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.11.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0> G0/B0 #				
_:1	V0> G0/B0 #:Mode		• off • on • test	off
_:2	V0> G0/B0 #:Operate & flt.rec. blocked		• no • yes	no
_:10	V0> G0/B0 #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	V0> G0/B0 #:Blk. w. inrush curr. detect.		• no • yes	no
_:110	V0> G0/B0 #:Blk. after fault extinction		• no • yes	yes
_:108	V0> G0/B0 #:Directional mode		• forward • reverse	forward
_:109	V0> G0/B0 #:Dir. measuring method		• G0 • B0	G0
_:107	V0> G0/B0 #:φ correction		-45 ° to 45 °	0 °
_:102	V0> G0/B0 #:Polarized G0/B0 threshold		0.10 mS to 100.00 mS	2.00 mS
_:105	V0> G0/B0 #:α1 reduction dir. area		1 ° to 15 °	2 °
_:106	V0> G0/B0 #:α2 reduction dir. area		1 ° to 15 °	2 °

Addr.	Parameter	C	Setting Options	Default Setting
_:101	V0> G0/B0 #:3I0> release thresh. value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:103	V0> G0/B0 #:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	V0> G0/B0 #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	V0> G0/B0 #:Operate delay		0.00 s to 60.00 s	2.00 s

6.11.8.4 Information List

No.	Information	Data Class (Type)	Type
V0> G0/B0 #			
_:81	V0> G0/B0 #:>Block stage	SPS	I
_:501	V0> G0/B0 #:>Block delay & op.	SPS	I
_:54	V0> G0/B0 #:Inactive	SPS	O
_:52	V0> G0/B0 #:Behavior	ENS	O
_:53	V0> G0/B0 #:Health	ENS	O
_:60	V0> G0/B0 #:Inrush blocks operate	ACT	O
_:55	V0> G0/B0 #:Pickup	ACD	O
_:56	V0> G0/B0 #:Operate delay expired	ACT	O
_:57	V0> G0/B0 #:Operate	ACT	O

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6.11.9 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

6.11.9.1 Description

Logic

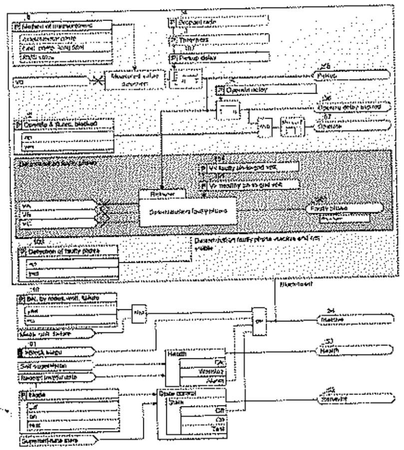

Figure 6-185 Logic Diagram of the Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Measured Value, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V_0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V_0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

Use the Method of measurement parameter to select the relevant method of measurement, depending on the application:

- Measurement of the fundamental component (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- Measurement of the fundamental component over 2 cycle filters with triangular window:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see 11.10.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage).

Pickup, Dropout

The stage compares the Threshold with the zero-sequence voltage V_0. The Pickup delay parameter allows you to delay the pickup of the stage depending on the residual voltage.
With the Dropout ratio parameter, you can define the ratio of the dropout value to the Threshold.

Determination of the Faulty Phase

With the Detection of faulty phase parameter, you can enable or disable the determination of the ground-fault phase. Determining is released when the stage picks up. If 2 phases exceed the threshold value V> healthy ph-to-gnd volt. and one phase falls below the threshold value V< faulty ph-to-gnd volt., the last phase is determined to be faulty and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal >Block stage from an external or internal source
- From inside on pickup of the measuring-voltage failure detection function. The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal >Open of the function block Voltage transformer circuit breaker, which links in the tripping of the voltage transformer circuit breaker. The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or not.

6.11.9.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Method of measurement

- Recommended setting value (_:8) Method of measurement = fundamental comp.

The Method of measurement parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).
fund. comp. long filter	To implement particularly strong damping of harmonics and transient faults, select this method of measurement. At 2 periods, the length of the filter is longer than that of the standard filter. Note that in this case the pickup time of the stage increases slightly (see 11.10.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage).

Parameter: Pickup delay

- Recommended setting value (_:107) Pickup delay = 0 ms

The Pickup delay parameter allows you to delay the analysis of the measurand (to prolong the pickup) depending on the occurrence of the residual voltage. A pickup delay can be necessary if high transients are anticipated after fault inception due to high line and ground capacitances.
Siemens recommends using the default setting Pickup delay = 0 ms.

Parameter: Threshold

- Default setting (_:3) Threshold = 30 V

The threshold value of the function is set as the zero-sequence voltage V_0. The device calculates the zero-sequence voltage V_0 either from the residual voltage measured via the broken-delta winding or from the 3 phase-to-ground voltages.
The setting value depends on the system grounding.

- Since virtually the full residual voltage occurs during ground faults in isolated or arc-suppression-coil-grounded systems, the setting value is uncritical there. Siemens recommends setting the value between 20 V and 40 V. A higher sensitivity (= lower threshold value) can be necessary for high fault resistances.
- Siemens recommends setting a more sensitive (smaller) value in grounded systems. This value must be higher than the maximum residual voltage anticipated during operation caused by system unbalances.

EXAMPLE
For an isolated system:
The residual voltage is measured via the broken-delta winding:
- If the ground fault is fully established, a residual voltage of 100 V is present at the device terminals.
- The threshold value should be set so that the stage picks up on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/√3 = 57.7 V.
  Setting value: 0.5 · 57.7 V = 28.9 V ≈ 30 V

Parameter: Dropout ratio

- Recommended setting value (_:4) Dropout ratio = 0.95

The recommended setting value of 0.95 is appropriate for most applications. To achieve high measurement precision, the dropout ratio can be reduced to 0.98, for example.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 3.00 s

The Operate delay allows you to prevent transient residual voltages from initiating a trip. The setting depends on the specific application.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.
A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and enabled
- The binary input signal >Open of the function block Voltage transformer circuit breaker is linked with the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked

Parameter: Detection of faulty phase

- Default setting (_:109) Detection of faulty phase = no

The Detection of faulty phase parameter controls how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults, for example for applications in grounded systems.
yes	After a pickup by the residual voltage, the device tries to determine which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: V< faulty ph-to-gnd volt.

- Default setting (_:104) V< faulty ph-to-gnd volt. = 30 V

Set the threshold value for determining which phase is affected by the ground fault in the V< faulty ph-to-gnd volt. parameter. The setting value is a phase-to-ground quantity.
The set value must be smaller than the minimum phase-to-ground voltage occurring during operation.
Siemens recommends using the default setting V< faulty ph-to-gnd volt. = 30 V.

Parameter: V> healthy ph-to-gnd volt.

- Default setting (_:101) V> healthy ph-to-gnd volt. = 70 V

Set the threshold value for the 2 healthy phases in the V> healthy ph-to-gnd volt. parameter. The setting value is a phase-to-ground measurand.
The set value must be above the maximum phase-to-ground voltage occurring during operation, but below the minimum phase-to-phase voltage present during operation. At V_{rated} = 100 V, the value has to be set to 70 V, for example. Siemens recommends using the default setting V> healthy ph-to-gnd volt. = 70 V.

Operation as Supervision Function

If you want the stage to have a reporting effect only, the generation of the operate indication and fault logging can be disabled via the (_:2) Operate & flt.rec. blocked parameter.

6.11.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0> #				
_:1	V0> #:Mode		off; on; test	off
_:2	V0> #:Operate & flt.rec. blocked		no; yes	no
_:10	V0> #:Blk. by meas.-volt. failure		no; yes	yes
_:109	V0> #:Detection of faulty phase		no; yes	no
_:8	V0> #:Method of measurement		fundamental comp.; fund. comp. long filter; RMS value	fundamental comp.
_:3	V0> #:Threshold		0.300 V to 200.000 V	30.000 V
_:4	V0> #:Dropout ratio		0.90 to 0.99	0.95
_:107	V0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	V0> #:Operate delay		0.00 s to 60.00 s	3.00 s
_:101	V0> #:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	70.000 V
_:104	V0> #:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	30.000 V

6.11.9.4 Information List

No.	Information	Data Class (Type)	Type
V0> #			
_:81	V0> #:>Block stage	SPS	I
_:54	V0> #:Inactive	SPS	O
_:52	V0> #:Behavior	ENS	O
_:53	V0> #:Health	ENS	O
_:300	V0> #:Faulty phase	ACT	O
_:55	V0> #:Pickup	ACD	O
_:56	V0> #:Operate delay expired	ACT	O
_:57	V0> #:Operate	ACT	O

6.11.10 Non-Directional 3I0 Stage

6.11.10.1 Description

In the Directional sensitive ground-fault detection function, the Non-directional 3I0 stage also works on demand.

Logic

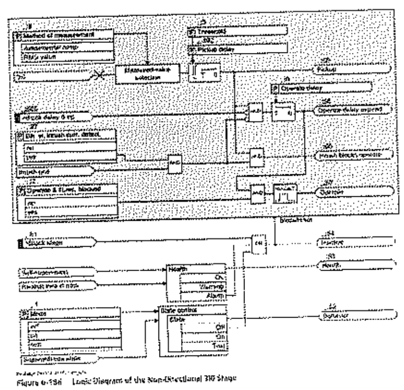

Figure 6-186 Logic Diagram of the Non-Directional 3I0 Stage

Measured Value 3I0

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.
Depending upon the settings of the Connection type and Measuring point I-3ph parameters, as well as the current terminal blocks used, different linearity and setting ranges result, refer for this to chapter 6.11.4.1 Description , Ground Fault Detection, Pickup.

Method of Measurement

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.

- 3I0 measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Tripping via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started.

6.11.10.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording and the fault log with the Operate & flt.rec. blocked parameter. In this case a ground-fault log is created instead of the fault log.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:27) Blk. w. inrush curr. detect = no

With the Blk. w. inrush curr. detect. parameter, you determine whether the tripping is blocked during the detection of an inrush current.

Parameter: Method of measurement

- Recommended setting value (_:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the Threshold value of the stage to less than 0.1 I_{rated}

Parameter: Threshold

- Default setting (_:3) Threshold = 0.090 A

The Threshold parameter allows you to set the threshold value of the ground current 3I0.

Parameter: Pickup delay

- Default setting (_:102) Pickup delay = 0.00 s

With the parameter Pickup delay you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 0.30 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.11.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> #				
_:1	3I0> #:Mode		• off • on • test	off
_:2	3I0> #:Operate & flt.rec. blocked		• no • yes	no
_:27	3I0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	3I0> #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	3I0> #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:102	3I0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	3I0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.11.10.4 Information List

No.	Information	Data Class (Type)	Type
3I0> #			
_:81	3I0> #:>Block stage	SPS	I
_:500	3I0> #:>Block delay & op.	SPS	I
_:54	3I0> #:Inactive	SPS	O
_:52	3I0> #:Behavior	ENS	O
_:53	3I0> #:Health	ENS	O
_:60	3I0> #:Inrush blocks operate	ACT	O
_:55	3I0> #:Pickup	ACD	O
_:56	3I0> #:Operate delay expired	ACT	O
_:57	3I0> #:Operate	ACT	O

6.11.11 Non-Directional Y0 Stage

6.11.11.1 Description

In the Directional sensitive ground-fault detection function, the Non-directional Y0 stage also works as desired.

Logic

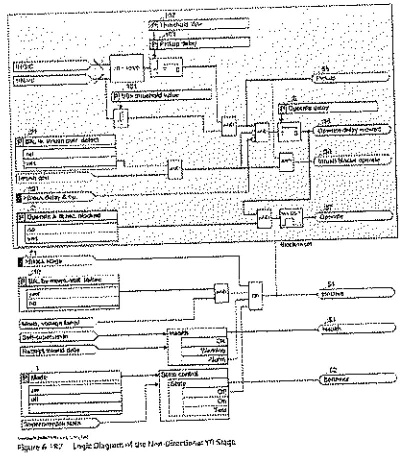

Figure 6-187   Logic Diagram of the Non-Directional Y0 Stage

Measured Value 3I0, Y0

The function evaluates the sensitively measured ground current 3I0 via a core balance current transformer, this current being converted with the voltage V0 into the admittance Y0=I0/V0. Since the linearity range of the

sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range. Depending on the settings of the Connection type and Measuring point I-3ph parameters, as well as the type of terminal block used, different linearity and setting ranges result, refer for this to chapter 6.11.8.1 Description.

Blocking the Stage via Binary Input Signal

Blocking of the stage is possible externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Voltage transformer circuit breaker, which links in the tripping of the voltage-transformer circuit breaker.

The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Indication via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started.

6.11.11.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected. A measuring-voltage failure can only be detected if 1 of the following 2 conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on.
- The binary input signal >Open of the function block Voltage-transformer circuit breaker is connected to the voltage transformer circuit breaker.

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.

Parameter Value	Description
no	The protection stage is not blocked.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:27) Blk. w. inrush curr. detect. = no

With the Blk. w. inrush curr. detect. parameter, you determine whether the operate is blocked during the detection of an inrush current.

Parameter: V0> threshold value

- Default setting (_:101) V0> threshold value = 5.000 V

The V0> threshold value parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: Threshold Y0>

- Default setting (_:102) Threshold Y0> = 2.00 mS

With the parameter Threshold Y0>, you set the threshold value of the ground admittance Y0. If the ground admittance for the setting value is unknown, you can assume the following relation:

$$Y0> \geq k_r \frac{I_{cap}}{3V_{ph-gnd}} + \frac{3I_{0,res}}{V0>}$$

[illegible]

k_r	Factor, takes into account the ohmic components of the current (1.2 for overhead lines, 1.05 for cable systems)
I_{cap}	Secondary capacitive ground-fault current for the protected line
V_{ph-gnd}	Secondary phase-to-ground voltage in the healthy case
$3I_{0,res}$	Secondary ground current in the healthy case (resulting from transformer errors), 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer)
$V0>$	Secondary pickup threshold of the residual voltage

Parameter: Pickup delay

- Default setting (_:103) Pickup delay = 0.00 s

With the parameter Pickup delay, you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 0.30 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.11.11.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Y0> #				
_:1	Y0> #:Mode		• off • on • test	off
_:2	Y0> #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:10	Y0> #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Y0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Y0> #:V0> threshold value		0.300 V to 200.000 V	5.000 V
_:102	Y0> #:Threshold Y0>		0.10 mS to 100.00 mS	2.00 mS
_:103	Y0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	Y0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.11.11.4 Information List

No.	Information	Data Class (Type)	Type
Y0> #			
_:81	Y0> #:>Block stage	SPS	I
_:501	Y0> #:>Block delay & op.	SPS	I
_:54	Y0> #:Inactive	SPS	O
_:52	Y0> #:Behavior	ENS	O
_:53	Y0> #:Health	ENS	O
_:60	Y0> #:Inrush blocks operate	ACT	O
_:55	Y0> #:Pickup	ACD	O
_:56	Y0> #:Operate delay expired	ACT	O
_:57	Y0> #:Operate	ACT	O

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6.12 Distance Protection

6.12.1 Overview of Functions

The Distance protection (ANSI 21, 21N) function is available in 2 variants:

- Distance protection for grounded systems with 1-phase tripping
- Distance protection for isolated/resonant-grounded systems with 3-phase tripping

NOTE

This section explains the basic design of the distance protection function. Descriptions of the 5 listed functions can be found in the line protection manual (C53000-G5040-C010):

- Distance protection with reactance method (RMD)
- Teleprotection with distance protection
- Teleprotection with ground-fault protection
- Echo and tripping in the event of weak infeed
- Automatic reclosing function

NOTE

When using the distance protection functions in transformer differential protection, the current transformer requirements of the line protection must be considered. You can find these in the line protection manual (C53000-G5040-C010).

6.12.2 Distance Protection for Grounded Systems

6.12.2.1 Overview of Functions

The function Distance protection for grounded systems (ANSI 21 N):

- Is a form of selective short-circuit protection for lines and cables supplied from one or more end(s) in radial, looped or meshed systems.
- Used as backup protection for busbars, transformers and other lines
- Works only in systems with grounded neutral point
- Trips 3-phase
- Suitable for use in all voltage levels

6.12.2.2 Structure of the Function

The function Distance protection for grounded systems can be placed in function groups that provide voltage and current measured values as well as line parameters.

The function Distance protection for grounded systems consists of the following blocks:

- General
- Pickup method
- Distance zones (preconfigured quadrilateral characteristic)
- Output logic 3-phase

The function Distance protection for grounded systems is preconfigured with 4 zones at the factory. The zones are structured identically. In the function Distance protection for grounded systems, a maximum of 16 zones with quadrilateral characteristic curve and 16 zones with MHO characteristic curve can be operated simultaneously.

The following figure shows the structural principles of the function Distance protection for grounded systems.

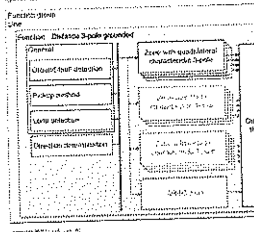

Figure 6-188 Structure/Embedding of the Function

Mode of Operation

Ground-fault detection determines whether a ground fault has occurred. The pickup method releases the measurement loops. For the released loops, the impedance is calculated. The calculated impedance is assigned to the operate curves (quadrilateral, MHO, or circular characteristic [1]) of the zones. In the impedance pickup method, the fault current is then analyzed and the apparent impedances eliminated. For all picked-up loops, the direction is then determined. The loop selection determines which loops are actually selected and which loops lie within the operate curves of the zones (loop pickup). All other loops are removed during loop elimination. For the picked up loops, the time delay in the zone logic is started. The zone logic forms the pickup and trip signals of the loops and phases for the zone. The output logic processes the pickup and trip signals of the zones and forms the pickup and trip signals of the distance protection.

Ground-Fault Detection

Ground-fault detection checks whether a ground fault has occurred. If a ground fault has occurred, the measuring elements for the phase-to-ground loops are released.

For ground-fault detection, the following criteria are available:

- Monitoring of the zero-sequence current $3I_0$
- Monitoring of the ratio of the zero-sequence current and negative-sequence current ($3I_0/3I_2$)
- Monitoring of the zero-sequence voltage V_0

Current and voltage criteria complement one another (see Figure 6-189). If the ratio of zero-sequence impedance to positive-sequence impedance is greater, zero voltage increases. If the ratio of zero-sequence impedance to positive-sequence impedance is small, the ground current increases. The Ground-fault detection parameter determines the criterion used to perform ground-fault recognition.

If a phase current leads to current-transformer saturation, the voltage criterion must be met for ground-fault detection. Uneven saturation of current transformers can lead to a secondary zero-sequence current without a primary zero-sequence current flowing. Automatic switching of the voltage criterion in the event of current-transformer saturation prevents unwanted ground-fault detection.

[1] In preparation

Ground-fault detection alone does not lead to the general pickup of the distance protection; it only controls other pickup modules. Ground-fault detection is also not indicated as its start.

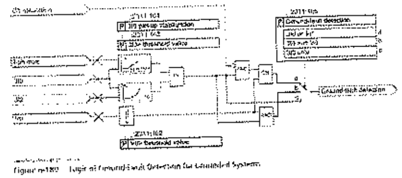

Figure 6-189 Logic of Ground-Fault Detection for Grounded Systems

Ground-Fault Detection: Zero-Sequence Current $3I_0$

The residual current criterion monitors the fundamental component of the sum of phase currents for exceeding a settable value (parameter 3I0> threshold value).

The residual-current criterion is stabilized against unwanted pickup for the following cases:

- Zero-sequence currents due to unbalanced load conditions
- Zero-sequence currents in the event of faults without ground contact due to differing saturation of phase-current transformers
- For detected current-transformer saturation (see Figure 6-189)

Figure 6-190 shows the pickup characteristic of the residual-current criterion. As phase currents increase, the actual pickup value rises automatically. The reset value is about 95 % of the pickup value.

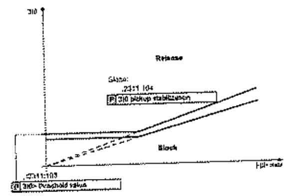

Figure 6-190 Residual-Current Criterion: Pickup Characteristic

Ground-Fault Detection: Zero-Sequence Current/Negative-Sequence Current ($3I_0/3I_2$)

For long, highly loaded lines, high load currents can lead to destabilization of the residual-current criterion (see Figure 6-190). For the detection of ground faults, the load-independent negative-sequence current criterion is extended. In addition to the zero-sequence current, the ratio of zero-sequence current to negative-sequence current is also monitored. In a 1-phase short circuit, the negative-sequence current I_2 is approximately as high as the zero-sequence current I_0. If the ratio of zero-sequence current to negative-sequence current exceeds a preset limit, the criterion is released. The zero-sequence current/negative-sequence current criterion is stabilized for high negative-sequence currents using a parabolic characteristic. Figure 6-191 shows the connection. A prerequisite for release of the zero-sequence current/negative-sequence current criterion is a minimum current of 0.2 I_{rated} for $3I_0$.

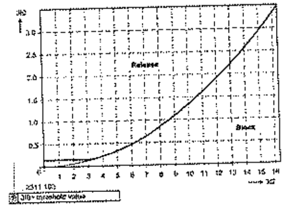

Figure 6-191 I0/I2 Criterion: Pickup Characteristic

Ground-Fault Detection: Zero-Sequence Voltage V_0

The zero voltage is monitored for exceeding a set value (parameter V0> threshold value). The reset value is about 95 % of the pickup value. In grounded systems, monitoring of the zero voltage can be used as an additional ground-fault criterion.

Pickup Method

The pickup method selects the fault loops to be considered.

Impedance pickup is preconfigured as the pickup method.

Zone Assignment

The calculated impedance vectors for the fault loops are assigned to the zones. For each zone, an operate curve is defined in the R-X plane. The following operate curves are available:

- Quadrilateral characteristic
- MHO characteristic curve

The description of operate curves can be found in sections 6.12.6 Zone with Quadrilateral Characteristic Curve and 6.12.7 Zone with MHO Characteristic Curve.

Direction Determination

You can define for each zone whether the zone should work forwards, backwards, or non-directional. For directional zones, you define the direction in the R-X plane. When assigning the impedance phasors in the

R-X plane, the direction is then additionally analyzed. The description can be found in chapter 6.12.4 Direction Determination.

Loop Selection in the Grounded System

In systems with effective or impedance-grounded neutral point, each contact of a phase with ground is a short-circuit-like process. The closest protection equipment must switch off the fault immediately. For double ground-fault protection, 2 phase-to-ground loops generally pick up. If both ground faults are in the same direction, this can also lead to pickup in the associated phase-to-phase loop. The Loop select. with phase-g parameter is used to restrict analysis to certain loops.

In a 3-phase short circuit, all phase-to-phase loops generally pick up. In this case, the 3 phase-to-phase loops are analyzed. If a ground fault is detected, the phase-to-ground loops are also analyzed.

Output Logic

The output logic of the function Distance protection for grounded systems links the output signals of the zones and forms the group trip signal of the function.

You can find the description of the output logic in chapter 6.12.8 Output Logic of the Distance Protection.

Influence of the Inrush-Current Detection

If the device is equipped with the Inrush-current detection function, the distance protection can be stabilized against tripping due to transformer-inrush currents. In case of interaction with the Inrush-current detection the following configurations are possible:

- Blocking of the pickup for the overcurrent pickup method, V-I pickup and V-I-φ pickup
- Blocking of individual distance zones
- Blocking of the pickup during impedance starting by blocking the external distance zone(s)

The Inrush-current detection can be configured individually for the blocking of the mentioned pickup methods and distance zones. In case of blocking, the distance zone that is linked to the inrush-current detection or the pickup method will not pick up. The function Inrush-current detection signals the blocking through a corresponding indication. Once the blocking drops out and the pickup condition for the respective method or the linked distance zone is met, the pickup is signaled and the corresponding time delay will start. After that time, the operate indication will be generated. Only if the central function Inrush-current detection (see section 6.51 Inrush-Current Detection) is active can the blocking be set.

6.12.2.3 Application and Setting Notes - General Settings

Set the following settings under General in the function Distance protection for grounded systems. The setting values are valid for all zones in the distance protection.

Parameter: Zone timer start

- Recommended setting value (_:2311:110) Zone timer start = on dist. pickup

The Zone timer start parameter is used to determine the time at which the time delays of the zones start.

Parameter Value	Description
on dist. pickup	If the time delays of all zones start simultaneously, select this setting. If the fault type or measurement loop selection changes, all time delays continue to run. Siemens recommends using this setting.
on zone pickup	The time delay for the zone starts with zone pickup. If you need to coordinate the function with other distance or overcurrent time protection functions, select this setting.

Parameter: Dist. characteristic angle

- Default setting (_:2311:107) Dist. characteristic angle = 85.0°

The Dist. characteristic angle parameter allows you to set the inclination angle of the distance protection characteristic curve (see Figure 6-209). The inclination angle set here for the distance protection characteristic curve applies to all zones in the function.

Siemens recommends setting the Dist. characteristic angle parameter to the line angle.

EXAMPLE:

Calculate the line angle from the data of the positive-sequence impedance on the line to be protected:

$Z_L = R_L + jX_L = (0.026 + j0.21)\ \Omega$

Line angle $= \arctan\left(\frac{X_L}{R_L}\right)$

Line angle = 83.2°

If you need to coordinate the function with other equipment, you can also set the inclination angle of the distance protection characteristic differently.

Parameter: Ground-fault detection

- Recommended setting value (_:2311:105) Ground-fault detection = 3I0 or V0

The Ground-fault detection parameter determines the criteria used to perform ground-fault detection.

Parameter Value	Description
3I0 or V0	If either the zero-sequence current criterion (3I0>) or the zero-sequence voltage criterion (V0>) leads to ground-fault detection, select this setting. For grounded systems, the OR operation of the criteria 3I0> and V0> is a reliable criterion for ground-fault detection. The criteria complement one another. For a weak infeed, the zero-sequence current is low and the zero-sequence voltage high. For a strong infeed, the conditions are reversed. Siemens recommends this setting for grounded networks.
3I0 and V0	If you wish to use both criteria for ground fault detection (logical AND operation of zero-sequence-current and zero-sequence voltage criteria), select this setting.
3I0 only	If only the zero-sequence current criterion is to be used for ground fault detection, select this setting.

Parameter: 3I0> threshold value

- Recommended setting value (_:2311:103) 3I0> threshold value = 0.10 A

The 3I0> threshold value parameter is used to define the zero-sequence current limit for ground fault detection.

The parameter 3I0> threshold value must be set to a value less than the lowest expected ground current in a ground fault on the protected feeder. For the distance protection to trigger for external remote faults as backup protection, set the 3I0> threshold value parameter to a more sensitive value than that necessary for internal faults. Siemens recommends keeping the setting value of 0.10 A.

Parameter: V0> threshold value

- Recommended setting value (_:2311:102) V0> threshold value = 1.66 V

The V0> threshold value parameter is used to define the zero-sequence voltage limit for ground fault detection.

For ground faults in a grounded system, there is a zero-sequence voltage. The zero-sequence voltage drops as the distance between the fault location and the measuring point increases. Siemens recommends maintaining a default setting of 1.66 V. If in your system imbalances can cause higher zero-sequence voltages to occur during operation, you can increase the default setting.

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Parameter: 3I0 pickup stabilization

- Recommended setting value (_:2311:104) 3I0 pickup stabilization = 0,10

The 3I0 pickup stabilization parameter is used to set the inclination of the 3I0> characteristic curve for ground-fault detection.

Power-system unbalance (for example, untwisted lines) and current-transformer errors can cause a residual current flow at the protection device in the case of higher phase currents, even if there is no ground fault. The 3I0 pickup stabilization parameter is used to avoid unwanted ground activation. If no extreme power-system unbalance and unusually large current-transformer errors are expected, Siemens recommends keeping the default value of 0,10.

Parameter: Loop select. with ph-ph-g

- Default setting (_:2311:108) Loop select. with ph-ph-g = block leading phase

The Loop select. with ph-ph-g parameter is used to determine which loops will be analyzed by the distance protection in the event of double ground faults. You can restrict the analysis to certain loops. If you wish to restrict analysis to certain loops, they must have the same direction.

In the case of a bilateral infeed to one common fault resistance with respect to ground, the phase-to-ground loop of the leading phase tends to overreach, that is, the leading phase-to-ground loop is measured too small. If you set the parameter Loop select. with ph-ph-g = block leading phase, these loops will not be analyzed.

The following table shows which loops are analyzed for different settings of the Loop select. with ph-ph-g parameter:

Parameter Value	Picked Up Loops	Evaluated Loop(s)
block leading phase	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A	B-gnd, A-B C-gnd, B-C A-gnd, C-A
block lagging phase	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A	A-gnd, A-B B-gnd, B-C C-gnd, C-A
all	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A
ph-ph only	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A	A-B B-C C-A
ph-gnd only	A-gnd, B-gnd, A-B B-gnd, C-gnd, B-C A-gnd, C-gnd, C-A	A-gnd, B-gnd B-gnd, C-gnd A-gnd, C-gnd

In a double line, ground faults may occur simultaneously on both lines. To avoid blocking of the internal fault loop, you must set the parameter Loop select. with ph-ph-g to ph-gnd only or all for this application. To ensure the selectivity of protection, reduce the range of the underreaching zone.

Parameter: Parallel-line compensat.

- Default setting (_:2311:106) Parallel-line compensat. = no

The Parallel-line compensat. parameter is used to determine for double circuit lines whether you wish to take into account the influence of the coupling impedance on the loop impedance or not.

NOTE

You can use the parameter Parallel-line compensat. only if the ground current of the parallel line is available in the Line function group. To do this, connect the measuring point I-1ph (ground current of the parallel line) to the Line function group in DIGSI 5.

NOTE

Only if you are working with MHO characteristic the following parameters will be visible:

- Mem. polarization(ph-g)
- Mem. polarization(ph-ph)
- Cross polarization(ph-g)
- Cross polarization(ph-ph)

The parameters apply to all MHO zones!

Parameter: Mem. polarization(ph-g)

- Default setting (_:2311:111) Mem. polarization(ph-g) = 15,0 %

With the Mem. polarization(ph-g) parameter, you can specify the degree of polarization with a buffered voltage for phase-to-ground loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the Mem. polarization(ph-g) parameter to 0,0 %.

Parameter: Mem. polarization(ph-ph)

- Default setting (_:2311:112) Mem. polarization(ph-ph) = 15,0 %

With the Mem. polarization(ph-ph) parameter, you can specify the degree of polarization with a buffered voltage for phase-to-phase loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the Mem. polarization(ph-ph) parameter to 0,0 %.

Parameter: Cross polarization(ph-g)

- Default setting (_:2311:113) Cross polarization(ph-g) = 15,0 %

With the Cross polarization(ph-g) parameter, you can specify the degree of polarization with an external-fault voltage for phase-to-ground loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the Cross polarization(ph-g) parameter to 0,0 %.

Parameter: Cross polarization(ph-ph)

- Default setting (_:2311:114) Cross polarization(ph-ph) = 15,0 %

With the Cross polarization(ph-ph) parameter, you can specify the degree of polarization with an external-fault voltage for phase-to-phase loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic curve without extension, set the Cross polarization(ph-ph) parameter to 0,0 %.

6.12.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:110	General:Zone timer start		• on zone pickup • on dist. pickup	on dist. pickup

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:101	General:Dist. characteristic angle		30,0 ° to 90,0 °	85,0 °
_:2311:105	General:Ground fault detection		• 3I0 or V0 • 3I0 and V0 • 3I0 only	3I0 or V0
_:2311:103	General:3I0> threshold value	1 A @ 100 Irated	0,030 A to 35,000 A	0,100 A
		5 A @ 100 Irated	0,15 A to 175,00 A	0,50 A
		1 A @ 50 Irated	0,030 A to 35,000 A	0,100 A
		5 A @ 50 Irated	0,15 A to 175,00 A	0,50 A
_:2311:102	General:V0> threshold value		0,300 V to 200,000 V	1,667 V
_:2311:104	General:3I0 pickup stabilization		0,05 to 0,30	0,10
_:2311:108	General:Loop select. with ph-ph-g		• block leading phase • block lagging phase • all • ph-ph only • ph-gnd only	block leading phase
_:2311:106	General:Parallel-line compensat.		• no • yes	no
_:2311:111	General:Mem. polarization(ph-g)		0,0 % to 100,0 %	15,0 %
_:2311:112	General:Mem. polarization(ph-ph)		0,0 % to 100,0 %	15,0 %
_:2311:113	General:Cross polarization(ph-g)		0,0 % to 100,0 %	15,0 %
_:2311:114	General:Cross polarization(ph-ph)		0,0 % to 100,0 %	15,0 %
Pickup Z<				
_:3661:101	Pickup Z<:Min. phase-current thresh	1 A @ 100 Irated	0,050 A to 35,000 A	0,100 A
		5 A @ 100 Irated	0,25 A to 175,00 A	0,50 A
		1 A @ 50 Irated	0,050 A to 35,000 A	0,100 A
		5 A @ 50 Irated	0,25 A to 175,00 A	0,50 A
_:3661:102	Pickup Z<:Use ph-g load cutout		• no • yes	no
_:3661:103	Pickup Z<:R load cutout (ph-g)	1 A	0,050 Ω to 600,000 Ω	25,000 Ω
		5 A	0,010 Ω to 120,000 Ω	5,000 Ω
_:3661:104	Pickup Z<:Angle load cutout (ph-g)		20,0 ° to 60,0 °	45,0 °
_:3661:105	Pickup Z<:Use ph-ph load cutout		• no • yes	no
_:3661:106	Pickup Z<:R load cutout (ph-ph)	1 A	0,050 Ω to 600,000 Ω	20,000 Ω
		5 A	0,010 Ω to 120,000 Ω	4,000 Ω
_:3661:107	Pickup Z<:Angle load cutout (ph-ph)		20,0 ° to 60,0 °	45,0 °
Z 1				
_:3571:1	Z 1:Mode		• off • on • test	off
_:3571:2	Z 1:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:3571:121	Z 1:Blocked if diff.prot.active		• no • yes	no
_:3571:27	Z 1:Blk. w. inrush curr. detect.		• no • yes	no
_:3571:101	Z 1:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3571:114	Z 1:Zone-spec. residu. comp.		• no • yes	no
_:3571:109	Z 1:Directional mode		• non-directional • forward • reverse	forward
_:3571:102	Z 1:X reach	1 A	0,050 Ω to 600,000 Ω	2,500 Ω
		5 A	0,010 Ω to 120,000 Ω	0,500 Ω
_:3571:103	Z 1:R (ph-g)	1 A	0,050 Ω to 600,000 Ω	2,500 Ω
		5 A	0,010 Ω to 120,000 Ω	0,500 Ω
_:3571:104	Z 1:R (ph-ph)	1 A	0,050 Ω to 600,000 Ω	1,250 Ω
		5 A	0,010 Ω to 120,000 Ω	0,250 Ω
_:3571:113	Z 1:Zone-inclination angle		0 ° to 45 °	0°
_:3571:110	Z 1:Operate delay (1-phase)		0,00 s to 60,00 s; ∞	0,00 s
_:3571:112	Z 1:Operate delay (multi-ph.)		0,00 s to 60,00 s; ∞	0,00 s
_:3571:105	Z 1:Kr		-0,33 to 11,00	1,00
_:3571:106	Z 1:Kx		-0,33 to 11,00	1,00
_:3571:107	Z 1:K0		0,000 to 11,000	1,000
_:3571:108	Z 1:Angle (K0)		-180,00 ° to 180,00 °	0,00 °
Z 2				
_:3572:1	Z 2:Mode		• off • on • test	off
_:3572:2	Z 2:Operate & flt.rec. blocked		• no • yes	no
_:3572:121	Z 2:Blocked if diff.prot.active		• no • yes	no
_:3572:27	Z 2:Blk. w. inrush curr. detect.		• no • yes	no
_:3572:101	Z 2:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3572:114	Z 2:Zone-spec. residu. comp.		• no • yes	no
_:3572:109	Z 2:Directional mode		• non-directional • forward • reverse	forward
_:3572:102	Z 2:X reach	1 A	0,050 Ω to 600,000 Ω	5,000 Ω
		5 A	0,010 Ω to 120,000 Ω	1,000 Ω
_:3572:103	Z 2:R (ph-g)	1 A	0,050 Ω to 600,000 Ω	5,000 Ω
		5 A	0,010 Ω to 120,000 Ω	1,000 Ω

Addr.	Parameter	C	Setting Options	Default Setting
_:3572:104	Z 2:R (ph-ph)	1 A	0,050 Ω to 600,000 Ω	2,500 Ω
		5 A	0,010 Ω to 120,000 Ω	0,500 Ω
_:3572:113	Z 2:Zone-inclination angle		0 ° to 45 °	0°
_:3572:110	Z 2:Operate delay (1-phase)		0,00 s to 60,00 s; ∞	0,30 s
_:3572:112	Z 2:Operate delay (multi-ph.)		0,00 s to 60,00 s; ∞	0,30 s
_:3572:105	Z 2:Kr		-0,33 to 11,00	1,00
_:3572:106	Z 2:Kx		-0,33 to 11,00	1,00
_:3572:107	Z 2:K0		0,000 to 11,000	1,000
_:3572:108	Z 2:Angle (K0)		-180,00 ° to 180,00 °	0,00 °
Z 3				
_:3573:1	Z 3:Mode		• off • on • test	off
_:3573:2	Z 3:Operate & flt.rec. blocked		• no • yes	no
_:3573:121	Z 3:Blocked if diff.prot.active		• no • yes	no
_:3573:27	Z 3:Blk. w. inrush curr. detect.		• no • yes	no
_:3573:101	Z 3:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3573:114	Z 3:Zone-spec. residu. comp.		• no • yes	no
_:3573:109	Z 3:Directional mode		• non-directional • forward • reverse	forward
_:3573:102	Z 3:X reach	1 A	0,050 Ω to 600,000 Ω	10,000 Ω
		5 A	0,010 Ω to 120,000 Ω	2,000 Ω
_:3573:103	Z 3:R (ph-g)	1 A	0,050 Ω to 600,000 Ω	10,000 Ω
		5 A	0,010 Ω to 120,000 Ω	2,000 Ω
_:3573:104	Z 3:R (ph-ph)	1 A	0,050 Ω to 600,000 Ω	5,000 Ω
		5 A	0,010 Ω to 120,000 Ω	1,000 Ω
_:3573:113	Z 3:Zone-inclination angle		0 ° to 45 °	0°
_:3573:110	Z 3:Operate delay (1-phase)		0,00 s to 60,00 s; ∞	0,60 s
_:3573:112	Z 3:Operate delay (multi-ph.)		0,00 s to 60,00 s; ∞	0,60 s
_:3573:105	Z 3:Kr		-0,33 to 11,00	1,00
_:3573:106	Z 3:Kx		-0,33 to 11,00	1,00
_:3573:107	Z 3:K0		0,000 to 11,000	1,000
_:3573:108	Z 3:Angle (K0)		-180,00 ° to 180,00 °	0,00 °
Z 4				
_:3574:1	Z 4:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:3574:2	Z 4:Operate & flt.rec. blocked		• no • yes	no
_:3574:121	Z 4:Blocked if diff.prot.active		• no • yes	no
_:3574:27	Z 4:Blk. w. inrush curr. detect.		• no • yes	no
_:3574:101	Z 4:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3574:114	Z 4:Zone-spec. residu. comp.		• no • yes	no
_:3574:109	Z 4:Directional mode		• non-directional • forward • reverse	non-directional
_:3574:102	Z 4:X reach	1 A	0,050 Ω to 600,000 Ω	12,000 Ω
		5 A	0,010 Ω to 120,000 Ω	2,400 Ω
_:3574:103	Z 4:R (ph-g)	1 A	0,050 Ω to 600,000 Ω	12,000 Ω
		5 A	0,010 Ω to 120,000 Ω	2,400 Ω
_:3574:104	Z 4:R (ph-ph)	1 A	0,050 Ω to 600,000 Ω	12,000 Ω
		5 A	0,010 Ω to 120,000 Ω	2,400 Ω
_:3574:113	Z 4:Zone-inclination angle		0 ° to 45 °	0°
_:3574:110	Z 4:Operate delay (1-phase)		0,00 s to 60,00 s; ∞	0,90 s
_:3574:112	Z 4:Operate delay (multi-ph.)		0,00 s to 60,00 s; ∞	0,90 s
_:3574:105	Z 4:Kr		-0,33 to 11,00	1,00
_:3574:106	Z 4:Kx		-0,33 to 11,00	1,00
_:3574:107	Z 4:K0		0,000 to 11,000	1,000
_:3574:108	Z 4:Angle (K0)		-180,00 ° to 180,00 °	0,00 °

6.12.2.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:54	General:Inactive	SPS	O
_:2311:53	General:Health	ENS	O
_:2311:300	General:Z ph-g	WYE	O
_:2311:301	General:Z ph-ph	DEL	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:301	Group indicat.:Selected loop AG	ACD	O
_:4501:302	Group indicat.:Selected loop BG	ACD	O
_:4501:303	Group indicat.:Selected loop CG	ACD	O
_:4501:304	Group indicat.:Selected loop AB	ACD	O
_:4501:305	Group indicat.:Selected loop BC	ACD	O
_:4501:306	Group indicat.:Selected loop CA	ACD	O

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No.	Information	Data Class (Type)	Type
Pickup Z<			
_:3661:51	Pickup Z<:Mode (controllable)	ENC	C
_:3661:52	Pickup Z<:Behavior	ENS	O
_:3661:53	Pickup Z<:Health	ENS	O
Z 1			
_:3571:81	Z 1:>Block stage	SPS	I
_:3571:500	Z 1:>Block ph-g loops	SPS	I
_:3571:501	Z 1:>Block ph-ph loops	SPS	I
_:3571:54	Z 1:Inactive	SPS	O
_:3571:52	Z 1:Behavior	ENS	O
_:3571:53	Z 1:Health	ENS	O
_:3571:55	Z 1:Pickup	ACD	O
_:3571:300	Z 1:Pickup loop AG	ACD	O
_:3571:301	Z 1:Pickup loop BG	ACD	O
_:3571:302	Z 1:Pickup loop CG	ACD	O
_:3571:303	Z 1:Pickup loop AB	ACD	O
_:3571:304	Z 1:Pickup loop BC	ACD	O
_:3571:305	Z 1:Pickup loop CA	ACD	O
_:3571:56	Z 1:Operate delay expired	ACT	O
_:3571:57	Z 1:Operate	ACT	O
Z 2			
_:3572:81	Z 2:>Block stage	SPS	I
_:3572:500	Z 2:>Block ph-g loops	SPS	I
_:3572:501	Z 2:>Block ph-ph loops	SPS	I
_:3572:54	Z 2:Inactive	SPS	O
_:3572:52	Z 2:Behavior	ENS	O
_:3572:53	Z 2:Health	ENS	O
_:3572:55	Z 2:Pickup	ACD	O
_:3572:300	Z 2:Pickup loop AG	ACD	O
_:3572:301	Z 2:Pickup loop BG	ACD	O
_:3572:302	Z 2:Pickup loop CG	ACD	O
_:3572:303	Z 2:Pickup loop AB	ACD	O
_:3572:304	Z 2:Pickup loop BC	ACD	O
_:3572:305	Z 2:Pickup loop CA	ACD	O
_:3572:56	Z 2:Operate delay expired	ACT	O
_:3572:57	Z 2:Operate	ACT	O
Z 3			
_:3573:81	Z 3:>Block stage	SPS	I
_:3573:500	Z 3:>Block ph-g loops	SPS	I
_:3573:501	Z 3:>Block ph-ph loops	SPS	I
_:3573:54	Z 3:Inactive	SPS	O
_:3573:52	Z 3:Behavior	ENS	O
_:3573:53	Z 3:Health	ENS	O
_:3573:55	Z 3:Pickup	ACD	O
_:3573:300	Z 3:Pickup loop AG	ACD	O
_:3573:301	Z 3:Pickup loop BG	ACD	O

No.	Information	Data Class (Type)	Type
_:3573:302	Z 3:Pickup loop CG	ACD	O
_:3573:303	Z 3:Pickup loop AB	ACD	O
_:3573:304	Z 3:Pickup loop BC	ACD	O
_:3573:305	Z 3:Pickup loop CA	ACD	O
_:3573:56	Z 3:Operate delay expired	ACT	O
_:3573:57	Z 3:Operate	ACT	O
Z 4			
_:3574:81	Z 4:>Block stage	SPS	I
_:3574:500	Z 4:>Block ph-g loops	SPS	I
_:3574:501	Z 4:>Block ph-ph loops	SPS	I
_:3574:54	Z 4:Inactive	SPS	O
_:3574:52	Z 4:Behavior	ENS	O
_:3574:53	Z 4:Health	ENS	O
_:3574:55	Z 4:Pickup	ACD	O
_:3574:300	Z 4:Pickup loop AG	ACD	O
_:3574:301	Z 4:Pickup loop BG	ACD	O
_:3574:302	Z 4:Pickup loop CG	ACD	O
_:3574:303	Z 4:Pickup loop AB	ACD	O
_:3574:304	Z 4:Pickup loop BC	ACD	O
_:3574:305	Z 4:Pickup loop CA	ACD	O
_:3574:56	Z 4:Operate delay expired	ACT	O
_:3574:57	Z 4:Operate	ACT	O

6.12.3 Distance Protection for Isolated/Resonant-Grounded Systems

6.12.3.1 Overview of Functions

The function **Distance protection for isolated or resonant-grounded systems** (ANSI 21 N):

- Is a form of selective short-circuit protection for lines and cables supplied from one or more end(s) in radial, looped or meshed systems,
- Works only in isolated or resonant-grounded systems via an arc-suppression coil
- Trips 3-phase
- Suitable for use in all voltage levels

6.12.3.2 Structure of the Function

The function **Distance protection for isolated or resonant-grounded systems** can be placed in function groups that provide voltage and current measured values as well as line parameters.

The function **Distance protection for isolated or resonant-grounded systems** consists of the following blocks:

- General
- Pickup method
- Distance zones (preconfigured quadrilateral characteristic)
- AREC zones (not preconfigured)
- Output logic 3-phase

The function **Distance protection for isolated or resonant-grounded systems** is preconfigured with 4 zones at the factory. The zones are structured identically. In the function **Distance protection for isolated or reso-**

nant-grounded systems, a maximum of 16 zones with quadrilateral characteristic curve and 16 zones with MHO characteristic curve can be operated simultaneously.

The following figure shows the structural principles of the function **Distance protection for isolated or resonant-grounded systems**.

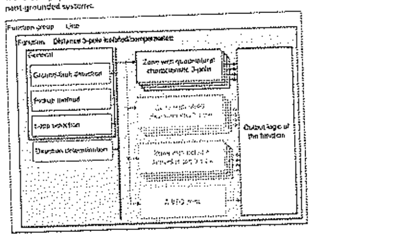


Figure 6-192 Structure/Embedding of the Function

Mode of Operation

Ground-fault detection determines whether a ground fault has occurred. The pickup method releases the measurement loops. For the released loops, the impedance is calculated. The calculated impedance is assigned to the operate curves (quadrilateral, MHO, or circular characteristic [1]) of the zones. In the impedance pickup method, the load cutout is then analyzed and the apparent impedances eliminated. For all picked up loops, the direction is then determined. The loop selection determines which loops are actually selected and which loops lie within the operate curve of the zones (loop pickup). All other loops are removed during loop elimination. For the picked up loops, the time delay in the zone logic is started. The zone logic forms the pickup and trip signals of the loops and phases for the zone. The output logic processes the pickup and trip signals of the zones and forms the pickup and trip signals of the distance protection.

Ground-Fault Detection

Ground-fault detection checks whether a ground fault has occurred. If a ground fault has occurred, the measuring elements for the phase-to-ground loops are released.

For ground-fault detection, the following criteria are available:

- Monitoring of the zero-sequence current $3I_0$
- Monitoring of the ratio of the zero-sequence current and negative-sequence current ($3I_0/3I_2$)
- Monitoring of the zero-sequence voltage V_0
- Monitoring of the balance of phase-to-phase voltages

In isolated/resonant-grounded systems, the pickup of ground-fault detection is unwanted for simple ground faults. In the event of 1-phase pickup, a simple ground fault is initially presumed. So that the starting oscillation upon occurrence of the ground fault does not lead to unwanted pickup of the function, the pickup is suppressed for a settable time. After the Delay 1-phase pickup time has expired, the pickup is released.

[1] In preparation

This is necessary so that the distance protection can still detect a double ground fault with a base point on a stub end feeder. If phase-to-phase voltages are unbalanced, a double ground fault can be assumed. In that case, pickup is released immediately. The balance criterion prevents unwanted pickup for a simple ground fault or unbalanced load conditions (see Figure 6-193). The Max. unbalance Vph-ph parameter specifies the maximum permitted unbalance for the load case, or in the event of a simple ground fault.

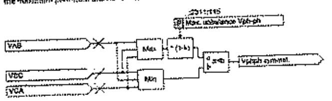


Figure 6-193 Balance Detection for Phase-to-Phase Voltages

Figure 6-194 shows the logic of the ground-fault detection in isolated or resonant-grounded systems.

If the following conditions are met, the ground-fault detection responds for double ground faults with very few ground currents:

- The zero-sequence current is 10 % of the measured negative-sequence current I_2
- The zero-sequence current is at least 5 % of the secondary rated current
- The phase-to-phase voltages are unbalanced

Monitoring of the balance of phase-to-phase voltages prevents unwanted pickup in the event of simple ground faults.

Only for current-transformer saturation, the zero-sequence voltage criterion is taken into account for the release of the ground-fault detection for double ground faults. If V0 exceeds the firmly set threshold of 0.73 V V_{nom}, the zero-sequence voltage criterion is released.

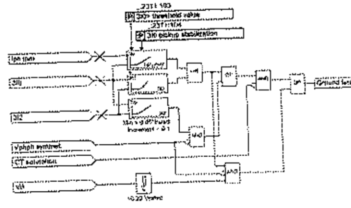


Figure 6-194 Ground-Fault Detection in Isolated or Resonant-Grounded Systems

Ground-fault detection: Zero-Sequence Current $3I_0$

The residual-current criterion monitors the fundamental component of the sum of phase currents for exceeding a settable value (parameter 3I0> threshold value).

The residual-current criterion is stabilized against unwanted pickup for the following cases:

- Zero-sequence currents due to unbalanced load conditions
- Zero-sequence currents in the event of faults without ground contact due to differing saturation of phase-current transformers
- For detected current-transformer saturation (see Figure 6-194)

Figure 6-195 shows the pickup characteristic of the zero-sequence current criterion. As phase currents increase, the actual pickup value rises automatically. The reset value is about 95 % of the pickup value.

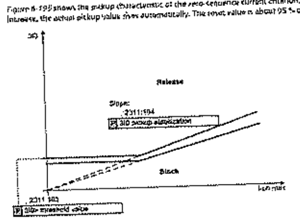


Figure 6-195 Residual-Current Criterion: Pickup Characteristic

Ground-Fault Detection: Zero-Sequence Current/Negative-Sequence Current ($3I_0/3I_2$)

For long lines, high load currents can lead to destabilization of the residual-current criterion (see Figure 6-195). For the detection of double ground faults, the load-independent negative-sequence current criterion is extended. In addition to the zero-sequence current, the ratio of zero-sequence current to negative-sequence current is also monitored. If the ratio of zero-sequence current to negative-sequence current exceeds a preset limit, the criterion is released. The zero-sequence current/negative-sequence current criterion is stabilized for high negative-sequence currents using a parabolic characteristic. Figure 6-196 shows the connection. A prerequisite for release of the zero-sequence current/negative-sequence current criterion is a minimum current of $0.2 \cdot I_{nom}$ for $3I_0$.

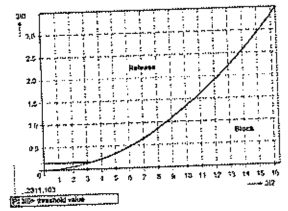


Figure 6-196 I0/I2 Criterion: Pickup Characteristic

Ground-Fault Detection: Zero-Sequence Voltage V_0

Only for current-transformer saturation, the zero-sequence voltage criterion is taken into account for the release of the ground-fault detection for double ground faults. If V0 exceeds the firmly set threshold of 0.73 V V_{nom}, the zero-sequence voltage criterion is released.

Pickup Method

The pickup method selects the fault loops to be measured.

Impedance pickup is preconfigured as the pickup method.

Zone Assignment

The calculated impedance vectors for the fault loops are assigned to the zones. For each zone, an operate curve is defined in the R X plane. The following operate curves are available:

- Quadrilateral characteristic (parallelogram)
- MHO characteristic curve

The description of operate curves can be found in sections 6.17.6 Zone with Quadrilateral Characteristic Curve and 6.17.7 Zone with MHO Characteristic Curve.

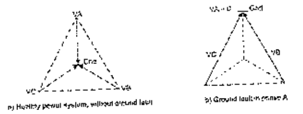
Direction Determination

You can define for each zone whether the zone should work forwards, backwards, or non-directional. For directional zones, you define the direction in the R X plane. When assigning the impedance phasors in the R X plane, the direction is then additionally analyzed. The description can be found in chapter 6.12.1 Direction Determination.

Loop Selection for Double Faults in Isolated/Resonant-Grounded Systems

In isolated or resonant-grounded systems, no short-circuit-like currents flow in the event of a 1-phase to ground fault. There is only a shift of the voltage triangle (see Figure 6-197). For system operation, this state is not an immediate danger. In the entire galvanically connected system, the voltage of the phase affected by the ground fault is approximately 0 V. Thus each load current gives an impedance of approximately 0 Ω. The distance protection may not respond in this case. A 1-phase phase-to-ground pickup without ground-current pickup is thus prevented.

709



a) Healthy power system, without ground fault
b) Ground fault in phase A

Figure 6-197 Ground Fault in the Non-Grounded System

If a ground fault occurs, a significant starting current can flow in an extended resonant-grounded system. This can result in a pickup of the ground current pickup. Special measures must be taken to prevent unwanted pickups when a ground fault occurs.

Specify a uniform double ground-fault preference for the galvanically contiguous system. This specifies which fault will be switched off.

For a double ground fault in the isolated or resonant-grounded system, it is enough to switch off one base point. The 2nd fault can remain in the system as a single ground fault. Specify a uniform double ground-fault preference for the galvanically contiguous system. This specifies which fault will be switched off. The Phase preferen. (ph-ph-g) parameter is used to define the order of preference. The following double ground fault preferences can be selected.

Setting for Parameter Phase preferen. (ph-ph-g)	Principle of Preference
C(A) acyclical	Acyclical C before A before B
A(C) acyclical	Acyclical A before C before B
B(A) acyclical	Acyclical B before A before C
A(B) acyclical	Acyclical A before B before C
C(B) acyclical	Acyclical C before B before A
B(C) acyclical	Acyclical B before C before A
C(A) cyclical	Cyclical C before A before B
A(C) cyclical	Cyclical A before C before B before A

In the 8 preference cases, a ground fault will be switched off according to the preference program. The 2nd fault remains as a simple ground fault in the system and can be detected using the Ground-fault detection function.

Influence of the Inrush-Current Detection

If the device is equipped with the Inrush-current detection function, the distance protection can be stabilized against tripping due to transformer-inrush currents. In case of interaction with the inrush-current detection the following configurations are possible:

- Blocking of the pickup for the overcurrent pickup method, V/I-pickup and V/I/φ-pickup
- Blocking of individual distance zones
- Blocking of the pickup during impedance starting by blocking the external distance zone(s)

The Inrush-current detection can be configured individually for the blocking of the mentioned pickup methods and distance zones. In case of blocking, the distance zone that is linked to the inrush-current detection or the pickup method will not pick up. The function Inrush-current detection signals the blocking through a corresponding indication. Once the blocking drops out and the pickup condition for the respective method or the linked distance zone is met, the pickup is signaled and the corresponding time delay will start. After that time, the operate indication will be generated. Only if the central function Inrush-current detection (see section 6.54 Inrush-Current Detection) is in effect can the blocking be set.

6.17.3.3 Application and Setting Notes - General Settings

Parameter: Zone timer start

- Recommended setting value (_:2311:110) Zone timer start = on dist. pickup

The Zone timer start parameter is used to determine the time at which the time delays of the zones start.

Parameter Value	Description
on dist. pickup	If the time delays of all zones start simultaneously, select this setting. If the fault type or measurement loop selection changes, all time delays continue to run. Siemens recommends using this setting.
on zone pickup	The time delay for the zone starts with zone pickup. If you need to coordinate the function with other distance or overcurrent-time protection functions, select this setting.

Parameter: Dist. characteristic angle

- Default setting (_:2311:107) Dist. characteristic angle = 85.0°

The Dist. characteristic angle parameter allows you to set the inclination angle of the distance protection characteristic curve (see Figure 6-205). The inclination angle set here for the distance protection characteristic curve applies to all zones in the function.

Siemens recommends setting the Dist. characteristic angle parameter to the line angle.

EXAMPLE:
Calculate the line angle from the data of the positive-sequence impedance (Z_L) on the line to be protected in the following way:

$Z_L = R_L + jX_L = (0.025 + j0.21)\ \Omega$

Line angle $= \arctan\left(\frac{X_L}{R_L}\right)$

Line angle $= 83.2°$

If you need to coordinate the function with other equipment, you can also set the inclination angle of the distance protection characteristic differently.

Parameter: 3I0> threshold value

- Recommended setting value (_:2311:103) 3I0> threshold value = 0.10 A

The 3I0> threshold value parameter is used to define the zero-sequence current limit for ground-fault detection.

Determine the maximum ground current for a simple ground fault. Set the parameter 3I0> threshold value to a slightly higher value.

Parameter: 3I0 pickup stabilization

- Recommended setting value (_:2311:104) 3I0 pickup stabilization = 0.10

The 3I0 pickup stabilization parameter is used to set the inclination of the 3I0> characteristic curve for ground-fault detection.

Power-system unbalance (for example, untwisted lines) and current-transformer errors can cause a residual current flow at the protection device in the case of higher phase currents, even if there is no ground fault. The 3I0 pickup stabilization parameter is used to avoid unwanted ground activation. If no extreme power-system unbalance and extraordinary current-transformer faults are expected, Siemens recommends keeping the recommended setting value of 0.10.

Parameter: Delay 1-phase pickup

- Default setting (_:2311:108) Delay 1-phase pickup = 0.04 s

The Delay 1-phase pickup parameter is used to delay pickup in the event of simple ground faults in the isolated/resonant-grounded system for the duration of the transient.

In resonant-grounded systems (neutral-point grounding through an arc-suppression coil), when a ground fault occurs, it leads to transient phenomena, transients. The starting oscillation can lead to pickup of the protection. The Delay 1-phase pickup parameter is used to delay the pickup.

Parameter: Phase preferen. (ph-ph-g)

- Default setting (_:2311:116) Phase preferen. (ph-ph-g) = C (A) acyclic

The Phase preferen. (ph-ph-g) parameter is used to define the order of preference for double ground faults.

The following table shows which loops are analyzed for different settings of the Phase preferen. (ph-ph-g) parameter:

Parameter Value	Activated Loop(s)	Analyzed Loop(s)
C (A) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd C-gnd C-gnd
A (C) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd C-gnd A-gnd
B (A) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	B-gnd B-gnd A-gnd
A (B) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd B-gnd A-gnd
C (B) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	B-gnd C-gnd C-gnd
B (C) acyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	B-gnd B-gnd C-gnd
C (A) cyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd B-gnd C-gnd
A (C) cyclic	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	B-gnd C-gnd A-gnd
all	A-gnd, B-gnd, (A-B) B-gnd, C-gnd, (B-C) A-gnd, C-gnd, (C-A)	A-gnd, B-gnd B-gnd, C-gnd C-gnd, A-gnd

If you wish to switch off both base points of a ground fault, set the parameter Phase preferen. (ph-ph-g) = all.

Parameter: Max. unbalance Vph-ph

- Default setting (_:2311:115) Max. unbalance Vph-ph = 25 %

The parameter Max. unbalance Vph-ph can be used to specify the maximum permitted unbalance for phase-to-phase voltages in the healthy condition. Determine the setting value for the specific application.

NOTE

Only if you are working with MHO characteristics, the following parameters will be visible:

- Mem. polarization(ph-g)
- Mem. polarization(ph-ph)
- Cross polarization(ph-g)
- Cross polarization(ph-ph)

The parameters apply to all MHO zones!

Parameter: Mem. polarization(ph-g)

- Default setting (_:2311:111) Mem. polarization(ph-g) = 15.0 %

With the Mem. polarization(ph-g) parameter, you can specify the degree of polarization with an external fault voltage for phase-to-ground loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic without extension, set the Mem. polarization(ph-g) parameter to 0.0 %.

Parameter: Mem. polarization(ph-ph)

- Default setting (_:2311:112) Mem. polarization(ph-ph) = 15.0 %

With the Mem. polarization(ph-ph) parameter, you can specify the degree of polarization with an external fault voltage for phase-to-phase loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic without extension, set the Mem. polarization(ph-ph) parameter to 0.0 %.

Parameter: Cross polarization(ph-g)

- Default setting (_:2311:113) Cross polarization(ph-g) = 15.0 %

With the Cross polarization(ph-g) parameter, you can specify the degree of polarization with an external fault voltage for phase-to-ground loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic without extension, set the Cross polarization(ph-g) parameter to 0.0 %.

Parameter: Cross polarization(ph-ph)

- Default setting (_:2311:114) Cross polarization(ph-ph) = 15.0 %

With the Cross polarization(ph-ph) parameter, you can specify the degree of polarization with an external fault voltage for phase-to-phase loops. This parameter influences the extension of the MHO characteristic curve depending on the source impedance. If you wish to work with the basic characteristic without extension, set the Cross polarization(ph-ph) parameter to 0.0 %.

6.17.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:110	General:Zone timer start		• on zone pickup • on dist. pickup	on dist. pickup
_:2311:107	General:Dist. characteristic angle		30.0 ° to 90.0°	85.0 °

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:103	General:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
_:2311:104	General:3I0 pickup stabilization		0.05 to 0.30	0.10
_:2311:108	General:Delay 1-phase pickup		0.00 s to 0.50 s	0.04 s
_:2311:116	General:Phase preferen. (ph-ph-g)		• C (A) acyclic • A (C) acyclic • C (B) acyclic • B (C) acyclic • A (B) acyclic • B (A) acyclic • C (A) cyclic • A (C) cyclic • all	C (A) acyclic
_:2311:115	General:Max. unbalance Vph-ph		5 % to 50 %	25 %
_:2311:111	General:Mem. polarization(ph-g)		0.0 % to 100.0 %	15.0 %
_:2311:112	General:Mem. polarization(ph-ph)		0.0 % to 100.0 %	15.0 %
_:2311:113	General:Cross polarization(ph-g)		0.0 % to 100.0 %	15.0 %
_:2311:114	General:Cross polarization(ph-ph)		0.0 % to 100.0 %	15.0 %
Pickup Z<				
_:3661:101	Pickup Z<:Min. phase-current thresh	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.25 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.25 A to 175.00 A	0.50 A
_:3661:102	Pickup Z<:Use ph-g load cutout		• no • yes	no
_:3661:103	Pickup Z<:R load cutout (ph-g)	1 A	0.050 Ω to 600.000 Ω	25.000 Ω
		5 A	0.010 Ω to 120.000 Ω	5.000 Ω
_:3661:104	Pickup Z<:Angle load cutout (ph-g)		20.0 ° to 60.0°	45.0 °
_:3661:105	Pickup Z<:Use ph-ph load cutout		• no • yes	no
_:3661:106	Pickup Z<:R load cutout (ph-ph)	1 A	0.050 Ω to 600.000 Ω	20.000 Ω
		5 A	0.010 Ω to 120.000 Ω	4.000 Ω
_:3661:107	Pickup Z<:Angle load cutout (ph-ph)		20.0 ° to 60.0°	45.0 °
Z 1				
_:3571:1	Z 1:Mode		• off • on • test	off
_:3571:2	Z 1:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:3571:121	Z 1:Blocked if diff.prot.active		• no • yes	no
_:3571:27	Z 1:Blk. w. inrush curr. detect.		• no • yes	no
_:3571:101	Z 1:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3571:114	Z 1:Zone-spec. residu. comp.		• no • yes	no
_:3571:109	Z 1:Directional mode		• non-directional • forward • reverse	forward
_:3571:102	Z 1:X reach	1 A	0.050 Ω to 600.000 Ω	2.500 Ω
		5 A	0.010 Ω to 120.000 Ω	0.500 Ω
_:3571:103	Z 1:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	2.500 Ω
		5 A	0.010 Ω to 120.000 Ω	0.500 Ω
_:3571:104	Z 1:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	1.250 Ω
		5 A	0.010 Ω to 120.000 Ω	0.250 Ω
_:3571:113	Z 1:Zone-inclination angle		0 ° to 45 °	0 °
_:3571:110	Z 1:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.00 s
_:3571:112	Z 1:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.00 s
_:3571:105	Z 1:Kr		-0.33 to 11.00	1.00
_:3571:106	Z 1:Kx		0.33 to 11.00	1.00
_:3571:107	Z 1:K0		0.000 to 11.000	1.000
_:3571:108	Z 1:Angle (K0)		-180.00 ° to 180.00 °	0.00 °
Z 2				
_:3572:1	Z 2:Mode		• off • on • test	off
_:3572:2	Z 2:Operate & flt.rec. blocked		• no • yes	no
_:3572:121	Z 2:Blocked if diff.prot.active		• no • yes	no
_:3572:27	Z 2:Blk. w. inrush curr. detect.		• no • yes	no
_:3572:101	Z 2:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3572:114	Z 2:Zone-spec. residu. comp.		• no • yes	no
_:3572:109	Z 2:Directional mode		• non-directional • forward • reverse	forward
_:3572:102	Z 2:X reach	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω
_:3572:103	Z 2:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω

Addr.	Parameter	C	Setting Options	Default Setting
_:3572:102	Z 2:R (ph-gnd)	1 A	0.050 Ω to 600.000 Ω	12.500 Ω
		5 A	0.010 Ω to 120.000 Ω	2.500 Ω
_:3572:113	Z 2:Zone-inclination angle		0° to 45°	0°
_:3572:110	Z 2:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:3572:112	Z 2:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s
_:3572:105	Z 2:Kr		-0.33 to 11.00	1.00
_:3572:106	Z 2:Kx		-0.33 to 11.00	1.00
_:3572:107	Z 2:K0		0.000 to 11.000	1.000
_:3572:108	Z 2:Angle (K0)		-180.00° to 180.00°	0.00°
Z 3				
_:3573:1	Z 3:Mode		• off • on • test	off
_:3573:2	Z 3:Operate & flt.rec. blocked		• no • yes	no
_:3573:121	Z 3:Blocked if diff.protection		• no • yes	no
_:3573:27	Z 3:Blk. w. inrush curr. detect.		• no • yes	no
_:3573:101	Z 3:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3573:114	Z 3:Zone spec. residu. comp.		• no • yes	no
_:3573:109	Z 3:Directional mode		• non-directional • forward • reverse	forward
_:3573:102	Z 3:X reach	1 A	0.050 Ω to 600.000 Ω	10.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.000 Ω
_:3573:103	Z 3:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	10.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.000 Ω
_:3573:104	Z 3:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	5.000 Ω
		5 A	0.010 Ω to 120.000 Ω	1.000 Ω
_:3573:113	Z 3:Zone-inclination angle		0° to 45°	0°
_:3573:110	Z 3:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.60 s
_:3573:112	Z 3:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.60 s
_:3573:105	Z 3:Kr		-0.33 to 11.00	1.00
_:3573:106	Z 3:Kx		-0.33 to 11.00	1.00
_:3573:107	Z 3:K0		0.000 to 11.000	1.000
_:3573:108	Z 3:Angle (K0)		-180.00° to 180.00°	0.00°
Z 4				
_:3574:1	Z 4:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:3574:2	Z 4:Operate & flt.rec. blocked		• no • yes	no
_:3574:121	Z 4:Blocked if diff.prot. active		• no • yes	no
_:3574:27	Z 4:Blk. w. inrush curr. detect.		• no • yes	no
_:3574:101	Z 4:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:3574:114	Z 4:Zone spec. residu. comp.		• no • yes	no
_:3574:109	Z 4:Directional mode		• non-directional • forward • reverse	non-directional
_:3574:102	Z 4:X reach	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω
_:3574:103	Z 4:R (ph-g)	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω
_:3574:104	Z 4:R (ph-ph)	1 A	0.050 Ω to 600.000 Ω	12.000 Ω
		5 A	0.010 Ω to 120.000 Ω	2.400 Ω
_:3574:113	Z 4:Zone-inclination angle		0° to 45°	0°
_:3574:110	Z 4:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.90 s
_:3574:112	Z 4:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.90 s
_:3574:105	Z 4:Kr		-0.33 to 11.00	1.00
_:3574:106	Z 4:Kx		-0.33 to 11.00	1.00
_:3574:107	Z 4:K0		0.000 to 11.000	1.000
_:3574:108	Z 4:Angle (K0)		-180.00° to 180.00°	0.00°

6.12.3.5 Information List

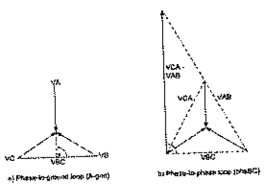
No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:54	General:Inactive	SPS	O
_:2311:53	General:Health	ENS	O
_:2311:300	General:Z ph-g	WYE	O
_:2311:301	General:Z ph-ph	DEL	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:301	Group indicat.:Selected loop AG	ACD	O
_:4501:302	Group indicat.:Selected loop BG	ACD	O
_:4501:303	Group indicat.:Selected loop CG	ACD	O
_:4501:304	Group indicat.:Selected loop AB	ACD	O
_:4501:305	Group indicat.:Selected loop BC	ACD	O
_:4501:306	Group indicat.:Selected loop CA	ACD	O

No.	Information	Data Class (Type)	Type
Pickup Z<			
_:3661:51	Pickup Z<:Mode (controllable)	ENC	C
_:3661:52	Pickup Z<:Behavior	ENS	O
_:3661:53	Pickup Z<:Health	ENS	O
Z 1			
_:3571:81	Z 1:>Block stage	SPS	I
_:3571:500	Z 1:>Block ph-g loops	SPS	I
_:3571:501	Z 1:>Block ph-ph loops	SPS	I
_:3571:54	Z 1:Inactive	SPS	O
_:3571:52	Z 1:Behavior	ENS	O
_:3571:53	Z 1:Health	ENS	O
_:3571:55	Z 1:Pickup	ACD	O
_:3571:300	Z 1:Pickup loop AG	ACD	O
_:3571:301	Z 1:Pickup loop BG	ACD	O
_:3571:302	Z 1:Pickup loop CG	ACD	O
_:3571:303	Z 1:Pickup loop AB	ACD	O
_:3571:304	Z 1:Pickup loop BC	ACD	O
_:3571:305	Z 1:Pickup loop CA	ACD	O
_:3571:56	Z 1:Operate delay expired	ACT	O
_:3571:57	Z 1:Operate	ACT	O
Z 2			
_:3572:81	Z 2:>Block stage	SPS	I
_:3572:500	Z 2:>Block ph-g loops	SPS	I
_:3572:501	Z 2:>Block ph-ph loops	SPS	I
_:3572:54	Z 2:Inactive	SPS	O
_:3572:52	Z 2:Behavior	ENS	O
_:3572:53	Z 2:Health	ENS	O
_:3572:55	Z 2:Pickup	ACD	O
_:3572:300	Z 2:Pickup loop AG	ACD	O
_:3572:301	Z 2:Pickup loop BG	ACD	O
_:3572:302	Z 2:Pickup loop CG	ACD	O
_:3572:303	Z 2:Pickup loop AB	ACD	O
_:3572:304	Z 2:Pickup loop BC	ACD	O
_:3572:305	Z 2:Pickup loop CA	ACD	O
_:3572:56	Z 2:Operate delay expired	ACT	O
_:3572:57	Z 2:Operate	ACT	O
Z 3			
_:3573:81	Z 3:>Block stage	SPS	I
_:3573:500	Z 3:>Block ph-g loops	SPS	I
_:3573:501	Z 3:>Block ph-ph loops	SPS	I
_:3573:54	Z 3:Inactive	SPS	O
_:3573:52	Z 3:Behavior	ENS	O
_:3573:53	Z 3:Health	ENS	O
_:3573:55	Z 3:Pickup	ACD	O
_:3573:300	Z 3:Pickup loop AG	ACD	O
_:3573:301	Z 3:Pickup loop BG	ACD	O

No.	Information	Data Class (Type)	Type
_:3573:302	Z 3:Pickup loop CG	ACD	O
_:3573:303	Z 3:Pickup loop AB	ACD	O
_:3573:304	Z 3:Pickup loop BC	ACD	O
_:3573:305	Z 3:Pickup loop CA	ACD	O
_:3573:56	Z 3:Operate delay expired	ACT	O
_:3573:57	Z 3:Operate	ACT	O
Z 4			
_:3574:81	Z 4:>Block stage	SPS	I
_:3574:500	Z 4:>Block ph-g loops	SPS	I
_:3574:501	Z 4:>Block ph-ph loops	SPS	I
_:3574:54	Z 4:Inactive	SPS	O
_:3574:52	Z 4:Behavior	ENS	O
_:3574:53	Z 4:Health	ENS	O
_:3574:55	Z 4:Pickup	ACD	O
_:3574:300	Z 4:Pickup loop AG	ACD	O
_:3574:301	Z 4:Pickup loop BG	ACD	O
_:3574:302	Z 4:Pickup loop CG	ACD	O
_:3574:303	Z 4:Pickup loop AB	ACD	O
_:3574:304	Z 4:Pickup loop BC	ACD	O
_:3574:305	Z 4:Pickup loop CA	ACD	O
_:3574:56	Z 4:Operate delay expired	ACT	O
_:3574:57	Z 4:Operate	ACT	O

6.12.4 Direction Determination

To determine the direction of a short circuit, an impedance phasor is used for each loop. Depending on the quality of the measurands, different calculation methods can be used. Immediately after a fault occurs, the short-circuit voltage is influenced by the compensating processes in the measured signals. Hence, the voltage buffered before the occurrence of the short circuit is used. If the steady-state short-circuit voltage (for a nearby fault) is also too small for direction determination, an unfaulted voltage is used. This is theoretically perpendicular to the actual short-circuit voltages. This applies both to phase-to-phase loops and to phase-to-ground loops (Figure 6-198). When calculating the directional vector, this is taken into account by a rotation of 90°. Table 6-6 shows the assignment of the measurands to the 6 fault loops for determining the direction.



a) Phase-to-ground loop (A-gnd)   b) Phase-to-phase loop (phBC)

[illegible]
Figure 6-198 Direction Determination with External Short-Circuit Voltages

Table 6-6 Assignment of Measurands for Direction Determination

Loop	Measured Current (Direction)	Actual Short-Circuit Voltage	External Short-Circuit Voltage
A-gnd	I_A	V_A	V_{BC}
B-gnd	I_B	V_B	V_{CA}
C-gnd	I_C	V_C	V_{AB}
A-gnd [illegible]	$I_A - I_{gnd}$ [illegible]	V_A	V_{BC}
B-gnd [illegible]	$I_B - I_{gnd}$ [illegible]	V_B	V_{CA}
C-gnd [illegible]	$I_C - I_{gnd}$ [illegible]	V_C	V_{AB}
A-B	$I_A - I_B$	V_{AB}	$V_{BC} - V_{CA}$
B-C	$I_B - I_C$	V_{BC}	$V_{CA} - V_{AB}$
C-A	$I_C - I_A$	V_{CA}	$V_{AB} - V_{BC}$

If the measured voltage is too small and no stored voltage is available, the direction is decided to be forward. If a dead line is connected and this line is faulty (for example, switching when the grounding switch is engaged), this case can occur.

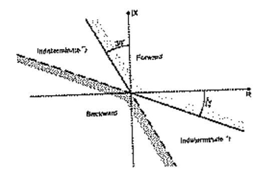
The theoretical steady-state direction characteristic curve is shown in Figure 6-199.

If buffered voltages are used, the following factors influence the position of the direction-characteristic curve:

- The source impedance
- The power transported on the line before occurrence of the short circuit

For this reason, the direction characteristic curve has a reserve distance from the limits of the first quadrant in the R-X diagram (Figure 6-199).

[illegible]



*) Also valid for non-directional

[illegible]
Figure 6-199 Direction-Characteristic Curve in the R-X Diagram

Since each zone can be set to forward, backward or non-directional, different (reflected through the center) direction characteristic curves are used for forward and backward. A non-directional zone has no direction characteristic curve. For such a zone, the entire trip region applies.

Features of Direction Determination

The theoretical steady-state direction-characteristic curve in Figure 6-199 applies for actual short-circuit voltages.

If external short-circuit or buffered voltages are used, the following factors influence the position of the direction characteristic curves:

- The source impedance
- The power transported on the line before occurrence of the short circuit

Figure 6-200 shows the direction-characteristic curve, taking the source impedance into consideration for external short-circuit or buffered voltages (without load transport). Since these voltages are equal to the corresponding generator voltage E, and they also do not change after the short circuit occurs, the direction-characteristic curve appears in the impedance diagram shifted by the source impedance ZS1 = E1/I1. For fault location F1 (Figure 6-200a), the short circuit lies in the forward direction, and the source impedance is in the backward direction. For all fault locations up to directly where the device is installed (current transformer), there is a consensus for forward (Figure 6-200b). If the current reverses, the orientation of the direction-characteristic curve changes suddenly (Figure 6-200c). A reversed current I2 now flows through the measuring point (current transformer). The source impedance ZS2 + ZL determines the value of I2. During load transport on the line, the direction-characteristic curve can also rotate by the load angle.

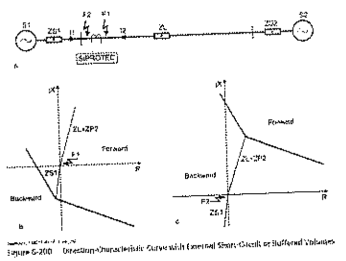


Figure 6-200 Direction-Characteristic Curve with External Short-Circuit or Buffered Voltages

Direction Determination for Series-Compensated Lines

The direction-characteristic curves and their shift by the source impedance also apply for lines with series capacitors. For a short circuit upstream of the local series capacitor, however, the short-circuit voltage reverses if the protective spark gap SF has not picked up (see Figure 6-201).

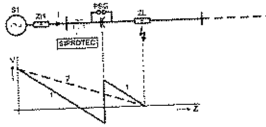


Figure 6-201 Voltage Characteristic for a Short Circuit Upstream of a Series Capacitor

(1) Without pickup of the protective spark gap
(2) With pickup of the protective spark gap

The distance protection thus senses a false fault direction, but in this case as well, direction measurement is correct due to the use of buffered voltages (see Figure 6-202a).

For direction determination, the voltage before the occurrence of the fault is used. Then the peaks of the direction characteristic curves, depending on the source impedance and load conditions before occurrence of the fault, appear shifted so far that the capacitor reactance does not lead to apparent reversal of direction (Figure 6-202b). The capacitor reactance is always lower than the source reactance.

If the short circuit is downstream of the capacitor – thus in reverse direction from where the device is installed (current transformer) – the peaks of the direction characteristic curve are shifted in the other direction (Figure 6-202c). This also ensures a correct direction determination in this case.

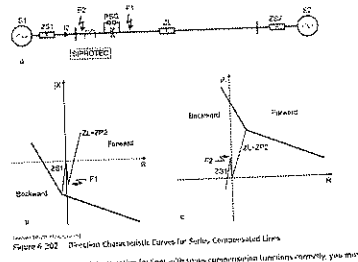


Figure 6-202 Direction Characteristic Curves for Series-Compensated Lines

So that the direction determination for lines with series compensation functions correctly, you must set the parameter Series compensation = yes in the Line function group.

6.12.5 Pickup Method: Impedance Pickup

6.12.5.1 Description

In impedance pickup, the phase currents are monitored. If the phase currents exceed the set Min. phase-current thresh., the impedances between the phase-to-phase loops are calculated. If a ground fault is detected, the impedances of the phase-to-ground loops are also calculated.

Impedance pickup includes the elimination of apparent impedance and – if activated – monitoring of the load cutout.

Healthy Loops

In impedance pickup, all 6 line loops are calculated. Here, the short-circuit currents and voltages of short-circuited lines also influence the impedances of the healthy loops. For an A-gnd fault, for example, the short-circuit current in line A also influences the measured values in measurement loops A-B and C-A. The ground current is also measured in loops B-gnd and C-gnd. Together with load currents flowing, so-called "apparent impedances" occur in the healthy loops. These have nothing to do with the actual troubleshooting.

These apparent impedances in the healthy loops are typically greater than the fault impedance of the short-circuit loop. The healthy loops contain only part of the short-circuit current, and always have a higher voltage than the faulty loop. They are therefore of no significance for the zone selectivity of the protection.

In addition to zone selectivity, phase selectivity is also important. Phase selectivity includes the identification of the faulty phase, the generation of phase-selective indications, and the possibility of executing a 1-pole automatic reclosing function (AREC). Depending on the infeed conditions, short circuits near the station may have the result that the healthy loops see the short circuit at a greater distance, but they still see it within a tripping area. This case leads to a disconnection without the option of a 1-pole AREC. The 3-pole disconnection of the line then results.

Impedance the loops reliably ensures zone and phase selectivity. Loops are inspected in 2 steps:

- From the calculated loop impedance and their partial impedances (phase or ground), a replication of the line is first simulated.
- If the replication is plausible, the corresponding loop activation is categorized as valid.

If the impedances of more than one loop lie within the zone range, the smallest is still declared valid. Further more, all loops are declared valid whose impedance is greater than the lowest impedance by not more than 50 %. Loops with greater impedances are eliminated. The exception is any loop declared plausible in the first step. These can then no longer be eliminated.

This eliminates healthy apparent impedances on the one hand, but on the other hand simultaneously detects unbalanced multiphase short circuits and multiple faults correctly. The loops found valid are converted into phase information. This allows the pickup to be signaled in a phase-selective manner.

Load Cutout

For long lines with high loads, there is a risk that the load impedance will be reflected in the operate curve of the distance protection. For operate curves with high R segments, a load cutout can be configured that eliminates unwanted pickups due to overload. The load cutout (see Figure 6-203) can be configured for phase-to-phase loops and for phase-to-ground loops.

The parameters are explained in chapter 6.12.5.2 Application and Setting Notes.

6.12.5.2 Application and Setting Notes

Parameter: Min. phase-current thresh

- Recommended setting value (_:101) Min. phase-current thresh = 0.10 A

Set the Min. phase-current thresh. parameter to a very sensitive value (10 % of I_{rated}). If the minimum phase current is exceeded, the distance protection calculates the impedance. The sensitive setting allows you to ensure the backup function of the distance protection in case of remote faults in other feeders. If the minimum phase current in case short circuits – depending on system conditions – is not exceeded, you will have to take special measures for the weak infeed. Siemens recommends using the default setting Min. phase-current thresh = 0.10 A.

Load Cutout

The load cutout can be set using the following parameters:

- Default setting (_:102) Use ph-g load cutout = yes
- Default setting (_:103) R load cutout (ph-g) = 20.000 Ω
- Default setting (_:104) Angle load cutout (ph-g) = 45.0°
- Default setting (_:105) Use ph-ph load cutout = yes
- Default setting (_:106) R load cutout (ph-ph) = 25.000 Ω
- Default setting (_:107) Angle load cutout (ph-ph) = 45.0°

The load cutout is set separately for phase-to-ground loops (ph-gnd) and phase-to-phase loops (ph-ph). Using the parameters Use ph-g load cutout and Use ph-ph load cutout, you specify whether the load range is cut out of the impedance level or not. The load cutout parameters are visible only if you set the parameters Use ph-g load cutout = yes and Use ph-ph load cutout = yes.

Since there is no residual current in the load, load conditions cannot lead to a ground pickup. In the event of a 1-pole tripping of neighboring circuits, there may simultaneously be a ground pickup and an increased load current. For these cases, the load cutout must be set for the ground characteristic.

In the impedance level, the load range must be separate from the tripping area of the distance zone. The zone may only respond under fault conditions, not under load conditions. For the specific application, calculate the smallest load impedance and the greatest load impedance angle under heavy load (see Figure 6-203).

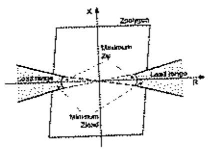


Figure 6-203 Load Cutout

The values should be set a little smaller (about 10 %) than the minimum load impedance expected. The minimum load impedance results at maximum load current and minimum operating voltage.

EXAMPLE

Calculation of load-cutout parameters in balanced load conditions

110 kV overhead line, 150 mm², with the data:

Maximum transmissible power	
P_{max}	= 100 MVA
I_{max}	= 525 A
Minimum operating voltage	
V_{min}	= 0.9 V_{rated}
Current transformer	600 A/5 A
Voltage transformer	110 kV/0.1 kV

The primary minimum load impedance is then calculated as follows:

$$R_{L,prim} = \frac{V_{min}}{I_{max}} = \frac{0.9 \cdot 110\ kV}{525\ A \cdot \sqrt{3}} = 108.9\ \Omega$$

The secondary minimum load impedance is then:

$$R_{L,sec} = \frac{Ratio_I}{Ratio_V} \cdot R_{L,prim} = \frac{600\ A/5\ A}{110\ kV/0.1\ kV} \cdot 108.9\ \Omega = 11.9\ \Omega$$

With a safety margin of 10 %, the following setting values result for setting the primary and secondary values:

Primary R load cutout (ph-ph) = 108.9 Ω or
Secondary R load cutout (ph-ph) = 11.9 Ω

Set the opening angle of the load cutout (parameters Angle load cutout (ph-ph) and Angle load cutout (ph-g)) greater (approx. 5°) than the maximum occurring load angle (corresponding to the minimum power factor cos φ).

EXAMPLE

Minimum power factor under heavy load ($cos\ \varphi_{min}$) = 0.8

φ_{min} = 36.9°

Setting value Angle load cutout (ph-ph) = φ_{max} + 5° = 41.9°

You can find additional setting notes in Example application high-voltage overhead line in 6.12.5.2 Application and Setting Notes.

When, with double lines, 2 line systems are on a single tower, there is a significant coupling between the 2 line systems. In the event of a 1-pole tripping of neighboring circuits, increased load currents and coupled ground currents can cause a ground pickup. This pickup can be prevented by separate setting of the load cutout for phase-to-ground loops.

During the 1-pole dead time on the parallel line, a significant ground current flows on the intact line. The ground current is caused by the coupling in the zero sequence system. The ground current during the 1-phase pause on the parallel line must be taken into consideration when setting the R load cutout (ph-g) parameter.

EXAMPLE

Calculation of the load-cutout parameters for an application on a double-circuit line

This example applies to a double line with zero sequence system coupling of both line systems and 1-pole tripping on one system in the double line.

The set values for the load cutout parameters are calculated for a 400-kV overhead line with the following data:

220 km double line on one tower (zero system coupling of both line systems)

Maximum load current per line with both lines in operation:

P_{max}	= 1200 MVA
I_{max}	= 1732 A
Minimum operating voltage V_{min}	= 0.9 V_{rated}
Current transformer	2000 A/5 A
Voltage transformer	400 kV/100 V
Parameter kE	= 1.54

The minimum load impedance results in:

$$Z_{L,prim} = \frac{V_{min}}{\sqrt{3} \cdot I_{max}} = \frac{0.9 \cdot 400\ kV}{\sqrt{3} \cdot 1732\ A} = 120\ \Omega$$

This calculated value applies to phase-to-phase loops. For double lines, the 1-pole dead time on the parallel line must also be taken into consideration for phase-to-ground loops. During the 1-pole dead time, the load current on the intact line increases. At the same time, a ground current flows in the ground path on the parallel line in the 1-pole dead time. Calculate the minimum load impedance for phase-to-ground loops with the load current at the ground path. For the calculation in this example, this ground current is given as a value relative to the load current I_{max}.

For the ratio of I_{gnd} on the healthy line to I_{max} in the 1-phase pause on the parallel line, the following value is assumed:

$$\frac{I_{gnd\ 1-phase\ Pause}}{I_{max}} = 0.4$$

The line lengths as well as the source impedance and line impedance have an influence on this ratio. If you cannot determine the value using a system simulation, you can assume the following approximate values:

Long lines (about 200 km): I_{ground}/I_{max} approximately 0.4

Short lines (about 25 km): I_{ground}/I_{max} approximately 0.6

The minimum load impedance for phase-to-ground loops results in the following for the calculation example:

$$R_{L,prim,ph-gnd} = \frac{R_{L,prim}}{1 + \frac{I_{gnd\ 1-phase\ Pause}}{I_{max}}(1 + k_E)} = \frac{120}{1 + 0.4 \cdot (1 + 1.54)} = 59.5\ \Omega$$

When parameterizing using PC and DIGSI, you can select to enter the values as the primary or secondary variables. Conversion into secondary values yields:

$$R_{L,sec} = \frac{Ratio_I}{Ratio_V} \cdot R_{L,prim} = \frac{2000/5}{400/0.1} \cdot 120\ \Omega = 12\ \Omega$$

$$R_{L,sec,ph-gnd} = \frac{Ratio_I}{Ratio_V} \cdot R_{L,prim,ph-gnd} = \frac{2000/5}{400/0.1} \cdot 59.5\ \Omega = 5.95\ \Omega$$

With a safety margin of 10%, these settings are used:

R load cutout (ph-ph)	= 108 Ω	(primary)	= 10.8 Ω	(secondary)
R load cutout (ph-g)	= 53.5 Ω	(primary)	= 5.35 Ω	(secondary)

The opening angle of the load cutout, as in the first example for the single line, is calculated using the minimum power factor.

6.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Pickup ZS				
_:101	Pickup Z<Min. phase-current thresh	1 A @ 100 Irated	0.050 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.25 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.050 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.25 A to 175.00 A	0.50 A
_:102	Pickup Z<Use ph-g load cutout		• no • yes	no
_:103	Pickup Z<R load cutout (ph-g)	1 A	0.100 Ω to 600.000 Ω	25.000 Ω
		5 A	0.020 Ω to 120.000 Ω	5.000 Ω
_:104	Pickup Z<Angle load cutout (ph-g)		20.0° to 60.0°	45.0°
_:105	Pickup Z<Use ph-ph load cutout		• no • yes	no
_:106	Pickup Z<R load cutout (ph-ph)	1 A	0.100 Ω to 600.000 Ω	20.000 Ω
		5 A	0.020 Ω to 120.000 Ω	4.000 Ω
_:107	Pickup Z<Angle load cutout (ph-ph)		20.0° to 60.0°	45.0°

6.12.5.4 Information List

No.	Information	Data Class (Type)	Type
Pickup ZS			
_:51	Pickup Z<Mode (controllable)	ENC	C

No.	Information	Data Class (Type)	Type
_:52	Pickup Z-Standard	ACD	O
_:53	Pickup Z-Standard	ACT	O

6.12.6 Zone with Quadrilateral Characteristic Curve

6.12.6.1 Description

Logic of a Zone

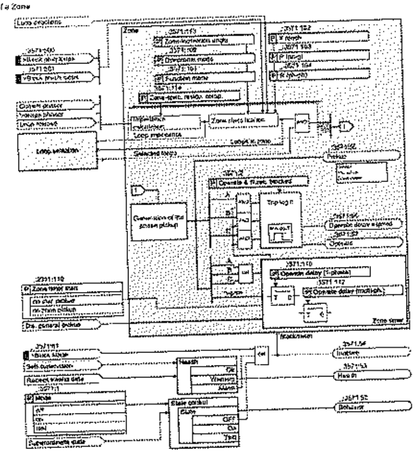


Figure 6-204 Logic Diagram of a Zone with a Quadrilateral Characteristic Curve

Mode of Operation

The zone handles the following tasks:

- Impedance calculation from the measured current and voltage values
- Placement of the impedance into the zone
- Generation of pickup and tripping for the zone

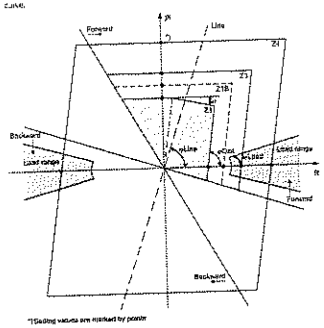
If the fault impedance of a loop lies well within the operating polygon at a distance zone, and the direction of the impedance phasor matches the directionality of the zone, the zone picks up. The loop information is converted into phase-selective pickup indications. The phase-selective pickup indications of the zones are processed further in the output logic of the distance protection and by external additional functions (for example, teleprotection schemes). The output logic of the distance protection is described in chapter 6.12.8 Output Logic of the Distance Protection.

Operating Polygon

The quadrilateral characteristic (operating polygon) of the zone is an inclined parallelogram in the R/X plane. The operating polygon is defined by the parameters X reach, R (ph-gnd), R (ph-ph) and Zone-inclination angle.

To stabilize the polygon limits, the characteristics have a hysteresis of 5 %. If the fault impedance lies within a polygon, the limits are increased by 5 % in all directions.

The following figure shows an example with 4 zones for the distance protection with quadrilateral operate curve.



*Setting values are marked by points

Figure 6-205 Operate Curve with Quadrilateral Characteristic

> **NOTE**
> You can rename or delete the zones in DIGSI. You can also add additional zones from the DIGSI function library.

6.12.6.2 Impedance Calculation

There is an impedance measuring element available for each of the 6 possible phase loops A-gnd, B-gnd, C-gnd, A-B, B-C, C-A.

A jump detection synchronizes all calculations to the occurrence of the fault. Synchronization enables stable and repeatable operate times to be achieved. If another fault occurs during analysis, the impedances are calculated using the current cyclical measurands. The analysis thus always works with the measurands of the current fault condition.

Impedance Calculation for Phase-to-Phase Loops

For calculation of a phase-to-phase loop, for example, for a 2-phase A-B short circuit (Figure 6-206), the loop equation is:

$$\underline{I}_A \cdot \underline{Z}_L - \underline{I}_B \cdot \underline{Z}_L = \underline{V}_{A\text{-gnd}} - \underline{V}_{B\text{-gnd}}$$

with

$\underline{V}, \underline{I}$	(complex) measurands
$\underline{Z}_L = R + jX$	(complex) line impedance

The line impedance is calculated as follows:

$$\underline{Z}_L = \frac{\underline{V}_{A\text{-gnd}} - \underline{V}_{B\text{-gnd}}}{\underline{I}_A - \underline{I}_B}$$

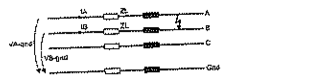


Figure 6-206 Short Circuit of a Phase-to-Phase Loop

As long as one of the lines involved is switched off, for example, during the 1-pole dead time of the automatic reclosing, the phase-to-phase loops involved are not calculated. During the 1-pole dead time of the automatic reclosing in A, for example, the loops A-B and C-A are blocked. This prevents an incorrect measurement with undefined measurands. The process monitor in the Line function group observes the state of the automatic reclosing and provides the blocking signal.

Impedance Calculation for Phase-to-Ground Loops

For calculation of a phase-to-ground loop, it must be considered that the impedance of the ground-return path generally does not match the impedance of the phases. This is the case, for example, for an C-gnd (Figure 6-207) short circuit.

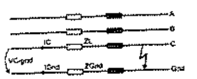


Figure 6-207 Short Circuit of a Phase-to-Ground Loop

The voltage $\underline{V}_{C\text{-gnd}}$, the phase current $\underline{I}_C$ and the ground current $\underline{I}_{gnd}$ of the faulty loop are measured.

$$\underline{V}_{C\text{-gnd}} = \underline{I}_C \cdot (R_{ph} + jX_{ph}) - \underline{I}_{gnd} \cdot (Kr \cdot R_{ph} + j(Kx \cdot X_{ph}))$$

The impedance at the location of the fault is calculated as:

$$R_{C\text{-gnd}} = \frac{V_{C\text{-gnd}}}{I_C} \cdot \frac{\cos(\varphi_V - \varphi_{ph}) - \frac{I_{gnd}}{I_C} \cdot kx \cdot \cos(\varphi_V - \varphi_{gnd})}{1 - (kx + kr) \cdot \frac{I_{gnd}}{I_C} \cdot \cos(\varphi_{gnd} - \varphi_{ph}) + kr \cdot kx \cdot \left(\frac{I_{gnd}}{I_C}\right)^2}$$

and

$$X_{C\text{-gnd}} = \frac{U_{C\text{-gnd}}}{I_C} \cdot \frac{\sin(\varphi_V - \varphi_{ph}) - \frac{I_{gnd}}{I_C} \cdot kr \cdot \sin(\varphi_V - \varphi_{gnd})}{1 - (kx + kr) \cdot \frac{I_{gnd}}{I_C} \cdot \cos(\varphi_{gnd} - \varphi_{ph}) + kr \cdot kx \cdot \left(\frac{I_{gnd}}{I_C}\right)^2}$$

with

$V_{C\text{-gnd}}$	Short-circuit voltage phasor
I_C	Short-circuit current phasor (phase C)
I_{gnd}	Ground-fault current phasor
φ_V	Phase angle of the short-circuit voltage
φ_{ph}	Phase angle of the short-circuit current (phase C)
φ_{gnd}	Phase angle of the ground-fault current

The factors $Kr = R_{gnd}/R_{ph}$ and $Kx = X_{gnd}/X_{ph}$ depend only on the line constants and not on the distance to the fault.

> **NOTE**
> In the impedance calculation, the factors Kr and Kx are used for residual compensation. If you enter the grounding resistance factors in the format K0 with Phi (K0), they are automatically converted into Kr and Kx. Conversion is performed under consideration of the line angle. For this reason, pay attention to the correct setting of the line angle in the general data of the Line function group (parameter (_:9001:108) Line angle).

As long as one of the phases involved is switched off, for example, during the 1-pole dead time of the automatic reclosing, the phase-to-ground loops involved are not calculated. During the 1-pole dead time in the automatic reclosing in C, the C-gnd loop is blocked, for example. This prevents an incorrect measurement with

undefined measurands. The process monitor observes the state of the automatic reclosing and provides the blocking signal.

Measured Value Correction for Parallel Lines

For double lines, both line systems are influenced by mutual coupling impedances (see Figure 6-208). With ground faults, errors in the results of the impedance calculation occur unless particular measures are taken. You can therefore effectively connect parallel-line compensation. This takes the ground current of the parallel line into consideration in the line equation, compensating for the coupling influence. This ground current must be applied to the device for this purpose. The loop equation in this case is similar to that of Figure 6-207:

$$\underline{I}_C \cdot \underline{Z}_L - \underline{I}_{gnd} \cdot \underline{Z}_{gnd} - \underline{I}_{gndP} \cdot (\underline{Z}_{M}/3) = \underline{V}_{C\text{-gnd}}$$

$$\underline{I}_C \cdot (R_L + jX_L) - \underline{I}_{gnd} \cdot (kr \cdot R_L + jkx \cdot X_L) - \underline{I}_{gndP} \cdot (kmR \cdot R_L + jkmX \cdot X_L) = \underline{V}_{C\text{-gnd}}$$

I_{gndP} is the ground current of the parallel line. The ratios $R_M/3R_L$ and $X_M/3X_L$ are line constants that result from the geometry of the double line and the suitability of the grounding.

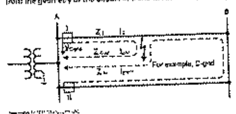


Figure 6-208 Ground Fault on a Double Line

Without parallel-line compensation, the ground current of the parallel line typically results in the underreaching of the distance protection (the loop impedance seen by the distance protection appears to be larger). If both lines end on different busbars and the grounding point is on a remote busbar (as B in Figure 6-208), overreach can result.

The parallel-line compensation applies only to faults on the line to be protected. Compensation may not be carried out for faults on the parallel line, since it would cause significant overreach. At installation point II in Figure 6-208, there must be no compensation for this fault situation.

The device thus requires an additional ground-current balance to perform a crosscomparison of the ground currents in both lines. The compensation is only connected for those lines where the ground current of the parallel line is less than that of the own line. In example Figure 6-208, Ignd II is greater than Ignd P. There is compensation in I in that ZM · IgndP is coupled in; in II there is no compensation.

6.12.6.3 Application and Setting Notes

Parameter: Blocked if diff.prot.active

- Recommended setting value (_:121) Blocked if diff.prot.active = no

The Blocked if diff.prot.active parameter is visible only when the line differential protection function is available in the application.

Using the Blocked if diff.prot.active parameter, you establish whether the distance protection zone is blocked or not as long as the line differential protection function is active.

Parameter Value	Description
no	If the zone is switched on (parameter Mode = on) and the parameter Blocked if diff.prot.active = no is set, the zone will run regardless of the line differential protection. If the zone picks up, it will generate an operate indication after the time delay has elapsed.
yes	If the zone is switched on (parameter Mode = on) and the Blocked if diff.prot.active = yes parameter is set, the zone is blocked as long as the line differential protection function is working. If the line differential protection is blocked, then the zone is not blocked.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:27) Blk. w. inrush curr. detect. = no

The Blk. w. inrush curr. detect. parameter is visible only when the inrush-current detection function is available in the application. With the Blk. w. inrush curr. detect. parameter, you determine whether the distance protection zone is blocked or not during the detection of a transformer inrush current.

> **NOTE**
> With the parameter Blk. w. inrush curr. detect. = yes set, the minimum pickup and operate time for this distance protection zone is about 1.5 system cyles even if no transformer inrush current is detected. Set the parameter Blk. w. inrush curr. detect. = yes only if you really need blocking on the basis of inrush current detection.

Parameter: Function mode

- Recommended setting value (_:101) Function mode = ph-gnd and ph-ph

You can use the Function mode parameter to determine which measuring elements the zone will work with. The possible alternatives are ph-gnd and ph-ph, ph-gnd only and ph-ph only.

Parameter Value	Description
ph-gnd and ph-ph	The zone works with phase-to-ground and phase-to-phase measuring elements. Siemens recommends using the default setting.
ph-gnd only	The zone works only with the phase-to-ground measuring element.
ph-ph only	The zone works only with the phase-to-phase measuring element.

Parameter: Directional mode

- Default setting (_:100) Directional mode = forward

You can use the Directional mode parameter to define whether the zone operates forward, reverse, or non-directional. Set the parameter Directional mode for the specific application.

Parameter: X reach

- Default setting (_:102) X reach = 2.500 Ω

You can use the X reach parameter to set the limit of the polygon in the X direction. Determine the setting value for the specific application.

First, create a time-grading schedule for the entire galvanically connected system. Enter the section lengths with their reactances X in Ω/km into the time grading schedule. The reactances X then define the range of the distance zones.

Further Notes on the Rx Ratio in the Zone Setting at the end of the section, you will find notes on the Rx setting.

You can find additional setting notes in Example applications: High-voltage overhead line

Parameter: R (ph-g)

- Default setting (_:107) R (ph-g) = 2.500 Ω

You can use the R (ph-g) parameter to set the polygon limits in the R direction for phase-to-ground loops. The R reach for ground faults is calculated in a manner similar to that used for R (ph-ph). Setting values for phase-to-phase faults. For phase-to-ground faults, the fault resistance is greater than that for phase-to-phase faults. For overhead lines, not only the arc resistance must be taken into consideration for a ground fault but also the tower grounding resistance.

Under Notes on the R/X Ratio in the Zone Setting at the end of the section, you will find notes on the R/X setting.

You can find additional setting notes in Example application: High-voltage overhead line.

Parameter: R (ph-ph)

- Default setting (_:104) R (ph-ph) = 1.250 Ω

You can use the R (ph-ph) parameter to set the polygon limits in the R direction for phase-to-phase loops. The R (ph-ph) setting value considers the fault resistance at the fault location. The fault resistance is added to the impedance of the fault loop as an additional effective resistance. This fault resistance is, for example, the arc resistance or the dissipation resistance of ground phases. Do not set the reserve resistance any larger than necessary. For long, heavily loaded lines, the setting value may enter the load range. A configurable load cutout prevents the activation of the zone in the event of overload (see Load cutout in chapter 6.12.5 Distance Impedance Pickup).

For overhead lines, the setting value is determined primarily by the arc resistance. No significant arc is possible in cables. With very short cables, ensure that the arc flashover at the local cable box is included in the set resistance for Zone 1.

Under Notes on the R/X Ratio in the Zone Setting at the end of the section, you will find notes on the R/X setting.

You can find additional setting notes in Example application: High-voltage overhead line.

Parameter: Operate delay (1-phase)

- Default setting (_:110) Operate delay (1-phase) = 0.00 s

You can use the Operate delay (1-phase) parameter to set the grading time of the zone for 1-phase short circuits. The Operate delay (1-phase) must be set for the specific application.

Parameter: Operate delay (multi-ph.)

- Default setting (_:112) Operate delay (multi-ph.) = 0.00 s

You can use the Operate delay (multi-ph.) parameter to set the grading time of the zone for multi-phase short circuits. The Operate delay (multi-ph.) must be set for the specific application.

Parameter: Zone-inclination angle

- Default setting (_:113) Zone-inclination angle = 0.0°

The Zone-inclination angle parameter is used to set the angle by which the upper limit of the polygon is inclined in the first quadrant.

Under no circumstances may Zone 1 respond in the event of external faults, since this represents a loss of selectivity. To prevent the loss of selectivity, the limit of the X setting for Zone 1 is inclined downwards by the set angle. The default angle of 0° is typically retained for greater distance zones.

You can find additional setting notes in Example application: High-voltage overhead line.

Parameter: Zone-spec. resid. comp.

- Default setting (_:114) Zone-spec. resid. comp. = no

You can use the Zone-spec. resid. comp. parameter to determine whether the zone operates with its own, specific residual compensation factors or not.

Parameter Value	Description
no	The zone works with the residual compensation factors set in the Line function group.
yes	The zone works with the specific residual compensation factors of the zone.

NOTE

Only if you set the parameter Zone-spec. resid. comp. = yes in the zone will the residual compensation factors set here be valid and visible. If you set the parameter Zone-spec. resid. comp. = no, the residual compensation factors set for the device apply.

Parameter: Kr and Kx

- Default setting (_:105) Kr = 1.00
- Default setting (_:106) Kx = 1.00

You can use the Kr and Kx parameters to set the residual compensation with scalar factors.

NOTE

The parameters Kr and Kx are visible in the zone only if you have set the parameter Zone-spec. resid. comp. = yes in the zone and the parameter Set. format residu. comp. = Kr, Kx for the device. You can only change the setting value of the parameter Set. format residu. comp. in DIGSI 5 under Device settings.

Parameter: K0 and Angle (K0)

- Default setting (_:3571:107) K0 = 1.000
- Default setting (_:3571:108) Angle (K0) = 0.00°

You can use the K0 and Angle (K0) parameters to set the residual compensation with the complex residual compensation factor.

NOTE

The parameters K0 and Angle (K0) are visible in the zone only if you have set the parameter Zone-spec. resid. comp. = yes in the zone and the parameter Set. format residu. comp. = K0 for the device. You can only change the setting value of the parameter Set. format residu. comp. in DIGSI 5 under Device settings.

Notes on the R/X Ratio in the Zone Setting

In practice, the ratio of the resistance to the reactance setting lies in the following ranges:

Section Type	R/X Ratio in the Zone Setting
Short cable sections (about 0.5 km to 3 km)	3 to 5
Longer cable sections (> 3 km)	2 to 3
Short overhead-line sections < 10 km	2 to 5
Overhead lines < 100 km	1 to 2
Long overhead lines 100 km to 200 km	0.5 to 1
Long extra-high voltage lines > 200 km	≤ 0.5

NOTE

For short lines with large R/X ratios, note the following during zone setting: The angle errors of the current and voltage transformers cause a rotation of the impedance measured in the direction of the R axis. The risk that external faults will be shifted into the first zone increases if, because of the settings for the polygon, R and X, the loop range is large in the R direction in relation to the X direction for Zone 1. Use the grading factor of 85 % only up to an R/X ratio ≤ 1 (loop range).

For larger R/X settings, you can calculate a reduced grading factor for Zone 1 using the following formula:

GF	Grading factor = range of Zone 1 relative to the line length
R	Loop range in the direction R for Zone 1 = R1 · (1 + kr)
X	Loop range in the direction X for Zone 1 = X1 · (1 + kx)
δ_U	Angle error of the voltage transformer (typically 1° [?])
δ_I	Angle error of the current transformer (typically 1° [?])

$$GF \leq \left[1 - \frac{R}{X} \cdot \tan(\delta_U + \delta_I)\right] \cdot 88.5\ \%$$

Alternatively or additionally, you can use the Zone-inclination angle parameter to incline the polygon of Zone 1 in the first quadrant. This also prevents overreach (see Figure 6-203).

6.12.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Z #				
_:1	Z #:Mode		• off • on • test	off
_:2	Z #:Operate & flt.rec. blocked		• no • yes	no
_:121	Z #:Blocked by diff prot. active		• no • yes	no
_:27	Z #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Z #:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:114	Z #:Zone-spec. resid. comp.		• no • yes	no
_:109	Z #:Directional mode		• non-directional • forward • reverse	forward
_:102	Z #:X reach	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:103	Z #:R (ph-g)	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:104	Z #:R (ph-ph)	1 A	0.100 Ω to 600.000 Ω	1.250 Ω
		5 A	0.020 Ω to 120.000 Ω	0.250 Ω
_:113	Z #:Zone-inclination angle		0° to 45°	0°
_:110	Z #:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:112	Z #:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
_:105	Z #:Kr		-0.33 to 11.00	1.00
_:106	Z #:Kx		-0.33 to 11.00	1.00
_:107	Z #:K0		0.000 to 11.000	1.000
_:108	Z #:Angle (K0)		-180.00° to 180.00°	0.00°

6.12.6.5 Information List

No.	Information	Data Class (Type)	Type
Z #			
_:81	Z #:>Block stage	SPS	I
_:500	Z #:>Block ph-g loops	SPS	I
_:501	Z #:>Block ph-ph loops	SPS	I
_:54	Z #:Inactive	SPS	O
_:52	Z #:Behavior	ENS	O
_:53	Z #:Health	ENS	O
_:55	Z #:Pickup	ACD	O
_:300	Z #:Pickup loop AG	ACD	O
_:301	Z #:Pickup loop BG	ACD	O
_:302	Z #:Pickup loop CG	ACD	O
_:303	Z #:Pickup loop AB	ACD	O
_:304	Z #:Pickup loop BC	ACD	O
_:305	Z #:Pickup loop CA	ACD	O
_:56	Z #:Operate delay expired	ACT	O
_:57	Z #:Operate	ACT	O

6.12.7 Zone with MHO Characteristic Curve

6.12.7.1 Description

Logic of a Zone

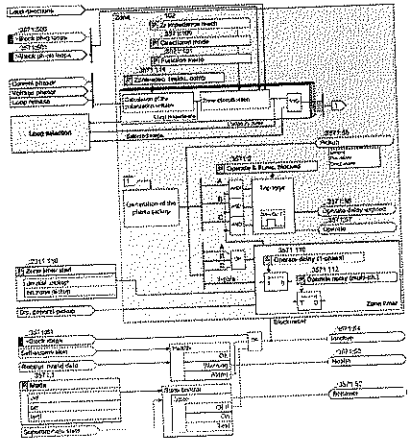


Figure 6-209 Logic Diagram of a Zone with MHO Characteristic Curve

Mode of Operation

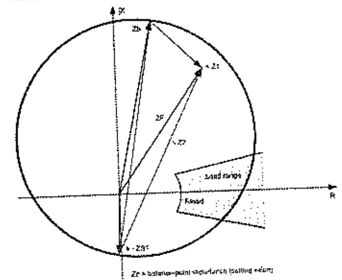
The zone handles the following tasks:

- Calculation of the polarization voltage from the measured current values
- Placement of the polarization and loop voltage into the zone
- Generation of pickup and tripping for the zone

To arrange the measurands at the blinding level of the MHO characteristic curve, the angle between 2 difference vectors ΔZ1 and ΔZ2 is determined (see Figure 6-210). These vectors are calculated from the difference between the 2 peaks of the circle's diameter and the fault impedance. The peak Zr corresponds to the setting value of the zone (parameter Zr impedance reach and angle in Figure 6-210); the peak k·ZV corresponds to the polarization value. The difference vectors are calculated as follows:

$$\Delta\underline{Z}_1 = \underline{Z}_F - \underline{Z}_r$$
$$\Delta\underline{Z}_2 = \underline{Z}_F - k \cdot \underline{Z}_V$$

In the boundary case, ZF is on the periphery of the circle. Then, the angle between the 2 difference vectors is 90° (Thales' theorem). Within the characteristic, the angle is greater than 90°; outside the characteristic, it is less than 90°.



Zr = balance-point impedance (setting value)
ZF = fault impedance
ZV = source impedance
k = evaluation factor for polarization voltage (parameterizable)

Figure 6-210 Vector Diagram of the Measurands for the MHO Characteristic Curve

The Zr impedance reach parameter is used to define the zone. With the parameter Directional mode, you can specify whether the zone works forward or reverse directed. In the reverse direction, the MHO characteristic curve is reflected across the coordinate origin. Since the fault impedance of a loop [illegible] within the MHO characteristic curve of a distance zone, the zone is set up. The loop polarization is concerned with phase selective pickup indications. The phase selection sets up indications of the zones are processed further in the output logic of the distance protection and by external additional functions (for example, teleprotection scheme). The output logic of the distance protection is described in chapter 6.12 Output Logic of the Distance Protection.

Basic Characteristic of the MHO Circuit

The basic form of the MHO characteristic curve is shown in Figure 6-211. The MHO characteristic curve of the zone is a circle through the coordinate origin in the R-X plane. The diameter is defined by the parameter Zr impedance reach. The inclination is defined by the parameter Zr Line characteristic angle.

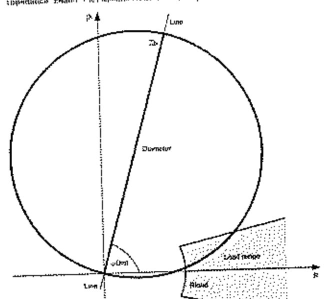
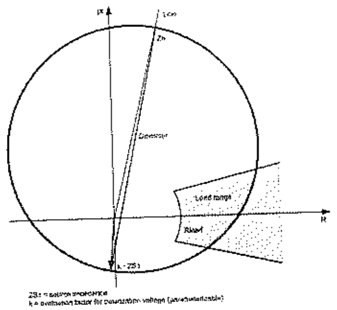


Figure 6-211 Basic Form of the MHO Characteristic Curve

Polarized MHO Characteristic Curve

The MHO characteristic curve passes through the coordinate origin. The boundary around the origin is undefined, since the measuring voltage there is too small for reliable analysis. The MHO characteristic curve is thus polarized. The polarization determines the lower peak of the circle, that is, the lower intersection of the diameter line on the circle circumference. The upper peak remains unchanged. It is defined by the parameter Zr impedance reach. Immediately after a fault occurs, the short-circuit voltage is influenced by the compensation procedure. Hence, the voltage buffered before the occurrence of the short circuit is used to perform the polarization. This shifts the lower peak by the impedance corresponding to the buffer voltage (see Figure 6-212). If the buffered short-circuit voltage is too small, a cross-polarized voltage is used. Theoretically, this is perpendicular to the actual short-circuit voltages for both the phase-to-ground loops and the phase-to-phase loops. This is taken into consideration with a 90° rotation during the calculation. The quadrature voltage also shifts the lower peak of the MHO characteristic curve.



ZS1 = source impedance
k = evaluation factor for polarization voltage (parameterizable)

Figure 6-212 Polarized MHO Characteristic Curve

Properties of the MHO Characteristic Curve

The cross-polarized or buffered voltage (without load transport) is equal to the corresponding generator voltage E. After the short circuit, it does not change (see also Figure 6-213). The lower peak of the circle's diameter thus appears shifted in the impedance diagram by the polarization value k·ZV1 = k·E1/I1. The upper peak remains defined by the setting value Zr impedance reach. For fault location F1 (Figure 6-213b), the short circuit lies in the forward direction, and the source impedance is in the reverse direction. All fault locations up to directly where the device is installed (current transformer) are unambiguously within the MHO characteristic (Figure 6-213b). If the current reverses, the peak of the diameter of the mho changes suddenly (Figure 6-213c). A reversed current I2 now flows through the measuring point (current transformer). The source impedance ZV2 + ZL determines the current I2. The peak Zr remains unchanged. It is now the lower limit of the diameter of the circle. During load transport on the line, the peak phasor can also rotate by the load angle.

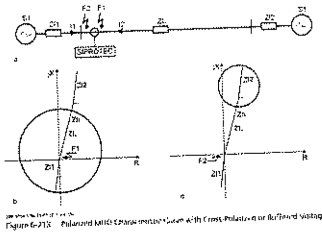


Figure 6-213 Polarized MHO Characteristic Curve with Cross-Polarized or Buffered Voltages

Selecting the Polarization

For short lines, the range of the zone must be set at a small value. For small loop voltages, the phase angle comparison between the differential voltage and the loop voltage is not secure. This can lead to incorrect directional decisions (tripping or blocking despite reverse faults). If a polarization voltage is used for the phase angle comparison, these problems are avoided. The polarization voltage is proportionally composed of the loop voltage buffered before the fault occurred and the present loop voltage. The following equation shows the polarization voltage V_p for a phase-to-ground loop:

$$V_p = (1 - k_{pre}) \cdot V_{ph\text{-}gnd} + k_{pre} \cdot V_{ph\text{-}gnd\ memory}$$

A value (factor k_{pre}) for the prefault voltage can be set separately for phase-to-ground and phase-to-phase loops. Memory polarization is only carried out when the RMS value of the corresponding buffer voltage for phase-to-ground loops is greater than 40 % of the rated voltage (V_{rated}). For phase-to-phase loops, the RMS value of the buffer voltage must be greater than 70 % of V_{rated}.

For a subsequent fault or after switching onto a fault, the prefault voltage can be missing. In this case, the buffer voltage can only be used for a limited time, for reasons of accuracy. For 1-phase short circuits and 2-phase short circuits without ground contact, you can use a voltage not involved in the fault for polarization. This voltage is rotated by 90° in relation to the actual fault voltage (cross polarization). The polarization voltage V_p is a mixture of the present voltage and the corresponding reference-fault voltage. The following equation shows the polarization voltage V_p for a phase-to-ground loop:

$$V_p = (1 - k_{cross}) \cdot V_{ph\text{-}gnd} + k_{cross} \cdot V_{ph\text{-}ph\ healthy}$$

If the buffer voltage is not available, then cross polarization can be used. An evaluation (factor k_{cross}) for the voltage can be set separately for phase-to-ground and phase-to-phase loops.

NOTE

The following parameters are available as evaluation factors for polarization:

- Mem. polarization (ph-g)
- Mem. polarization (ph-ph)
- Cross polarization (ph-g)
- Cross polarization (ph-ph)

Set the parameters for all zones in the general parameters of the Distance protection function.

6.12.7.2 Application and Setting Notes

Parameter: Blocked if diff.prot.active

- Recommended setting value (_:121) Blocked if diff.prot.active = no

The Blocked if diff.prot.active parameter is visible only when the Line differential protection function is available in the application.
You can use the Blocked if diff.prot.active parameter to establish whether the distance protection zone is blocked or not as long as the Line differential protection function is active.

Parameter Value	Description
no	If the zone is switched on (parameter Mode = on) and the parameter Blocked if diff.prot.active = no is set, the zone will run regardless of the line differential protection. If the zone picks up, it will generate an operate indication after the time delay has elapsed.
yes	If the zone is switched on (parameter Mode = on) and the Blocked if diff.prot.active = yes parameter is set, the zone is blocked as long as the line differential protection function is working. If the line differential protection is blocked, then the zone is not blocked.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:27) Blk. w. inrush curr. detect. = no

The Blk. w. inrush curr. detect. parameter is visible only when the Inrush-current detection function is available in the application. You can use the Blk. w. inrush curr. detect. parameter to determine whether the distance protection zone is blocked or not during the detection of a transformer inrush current.

NOTE

With the parameter Blk. w. inrush curr. detect. = yes, the minimum pickup and operate time for the distance protection zone is 1.5 power-system cycles even if the transformer inrush current is detected. Set the parameter Blk. w. inrush curr. detect. = yes only if you really need blocking on the basis of inrush-current detection.

Parameter: Function mode

- Recommended setting value (_:101) Function mode = ph-gnd and ph-ph

You can use the Function mode parameter to determine which measuring element the zone will work with. The possible alternatives are ph-gnd and ph-ph, ph-gnd only and ph-ph only.

Parameter Value	Description
ph-gnd and ph-ph	The zone works with phase-to-ground and phase-to-phase measuring elements. Siemens recommends using the default setting.

Parameter Value	Description
ph-gnd only	The zone works only with the phase-to-ground measuring element.
ph-ph only	The zone works only with the phase-to-phase measuring element.

Parameter: Directional mode

- Recommended setting value (_:109) Directional mode = forward

You can use the Directional mode parameter to specify whether the zone works forward or reverse. Set the parameter Directional mode for the specific application.

Parameter: Zr impedance reach

- Recommended setting value (_:102) Zr impedance reach = 2.500 Ω

You can use the Zr impedance reach parameter to define the reach of the zone. Determine the setting value for the specific applications.
First, create a time-grading schedule for the entire galvanically connected system. Enter the section lengths with their primary reactances X in Ohm into the time-grading schedule. The reactances X then define the range of the distance protection zones.

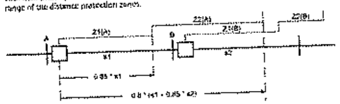


Figure 6-214 Setting of the Range – Example for Device A

Set the range of Zone Z1 to about 85 % of the line section to be protected. Zone Z1 should trip quickly. Set the time delay of Zone Z1 to 0.00 s. The protection then switches off faults at this distance with its operating time. For higher levels, increase the time delay by 1 grading time increment.
The grading time must take the following factors into consideration:

- Circuit-breaker operating time including variation
- Dropout time for protection systems
- Variations in time delays

The usual grading times are 0.2 s to 0.4 s. Set the range of Zone Z2 to a value that extends to about 80 % of the lowest-level zone of the protection for the shortest subsequent line (see Figure 6-214).
When parameterizing using PC and DIGSI, you can select to enter the values in either primary or secondary variables. If you wish to enter secondary variables during parameterization, convert the primary values from the time grading schedule into secondary values as follows:

$$Z_{secondary} = \frac{Ratio_I}{Ratio_V} \cdot Z_{primary}$$

6.12.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Z (MHO) #				
_:1	Z (MHO) #:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2	Z (MHO) #:Operate & flt.rec. blocked		• no • yes	no
_:121	Z (MHO) #:Blocked if diff.prot.active		• no • yes	no
_:27	Z (MHO) #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Z (MHO) #:Function mode		• ph-gnd and ph-ph • ph-gnd only • ph-ph only	ph-gnd and ph-ph
_:114	Z (MHO) #:Zone-spec. resid. comp.		• no • yes	no
_:109	Z (MHO) #:Directional mode		• forward • reverse	forward
_:102	Z (MHO) #:Zr impedance reach	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:110	Z (MHO) #:Operate delay (1-phase)		0.00 s to 60.00 s; ∞	0.30 s
_:112	Z (MHO) #:Operate delay (multi-ph.)		0.00 s to 60.00 s; ∞	0.30 s
_:105	Z (MHO) #:Kr		-0.33 to 11.00	1.00
_:106	Z (MHO) #:Kx		-0.33 to 11.00	1.00
_:107	Z (MHO) #:K0		0.000 to 11.000	1.000
_:108	Z (MHO) #:Angle (K0)		-180.00° to 180.00°	0.00°

6.12.7.4 Information List

No.	Information	Data Class (Type)	Type
Z (MHO) #			
_:81	Z (MHO) #:>Block stage	SPS	I
_:500	Z (MHO) #:>Block ph-g loops	SPS	I
_:501	Z (MHO) #:>Block ph-ph loops	SPS	I
_:54	Z (MHO) #:Inactive	SPS	O
_:52	Z (MHO) #:Behavior	ENS	O
_:53	Z (MHO) #:Health	ENS	O
_:55	Z (MHO) #:Pickup	ACD	O
_:300	Z (MHO) #:Pickup loop AG	ACD	O
_:301	Z (MHO) #:Pickup loop BG	ACD	O
_:302	Z (MHO) #:Pickup loop CG	ACD	O
_:303	Z (MHO) #:Pickup loop AB	ACD	O
_:304	Z (MHO) #:Pickup loop BC	ACD	O
_:305	Z (MHO) #:Pickup loop CA	ACD	O
_:56	Z (MHO) #:Operate delay expired	ACT	O
_:57	Z (MHO) #:Operate	ACT	O

ВЯРНО С ОРИГИНАЛА

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6.12.8 Output Logic of the Distance Protection

Mode of Operation

The output logic treats the pickup and trip signals of the distance zones separately, in one pickup logic and one trip logic each. The pickup and trip logic generate the superordinate indications of the distance protection.

General Pickup

In impedance pickup, the signal *General* is generated once a fault is reliably detected in the working area of a zone. In the pickup methods I>, V< and V/I/φ, the signal *General* is generated when a pickup condition is met.

The signal *General* is indicated and can be further processed by internal and external additional functions, for example, teleprotection scheme or automatic reclosing.

Pickup Logic

The distance zone pickups are combined phase-selectively and output as indications.

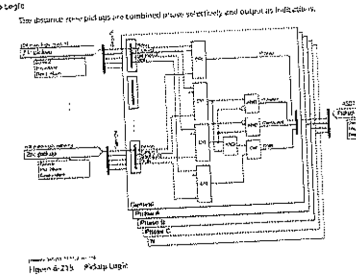


Figure 6-215 Pickup Logic

Trip Logic

The trip signals of the distance zones always lead to a 3-phase operate indication of the distance protection.

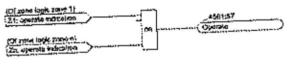


Figure 6-216 3-Phase Trip Logic

6.13 Impedance Protection

6.13.1 Overview of Functions

The Impedance protection function (ANSI 21):
- Protects transformers as backup protection for transformer differential protection
- Is used as backup protection for the block transformer and the generator in block unit power stations
- Functions as backup protection in the event of energy recovery to faults in the upstream electrical power system beyond a transformer

6.13.2 Structure of the Function

The Impedance protection function is used in protection function groups which provide current and voltage measurement values.

The Impedance protection function is preconfigured at the factory with the function block (FB) General and one zone. A maximum of 4 zones can be operated simultaneously in the function. The zones are structured identically.

The protection function is structured in that way that the settings in the FB General are valid for all zones.

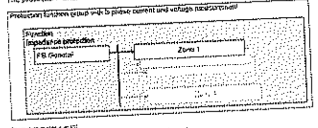


Figure 6-217 Structure/Embedding of the Function

6.13.3 Description

Impedance Measurement via the Transformer

Pay attention to the following features when measuring impedance in or via transformers:
- Impedance is transferred to the side to be measured using the quadrant of the transformer ratio.
- For star-delta transformers, an opposite phase rotation occurs in the positive sequence and negative-sequence system, depending on the vector group. This changes the fault situation on the other side. A 2-phase short circuit on the star side appears as a 3-phase short circuit with different current distribution on the delta side (see Figure 6-218).
  Since star-delta transformers do not permit the zero-sequence system to be transferred, a 1-phase ground fault on the star side appears as a 2-phase short circuit on the delta side (see Figure 6-219).
- In the case of auto transformers and transformers grounded on both sides in the star-star connection, measurement through the transformer is possible. Here, distance protection for lines can be used without any problems.

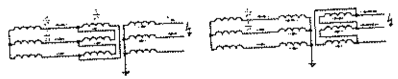


Figure 6-218 Transformation of a 2-Phase Short-Circuit Current

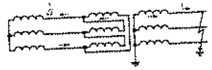


Figure 6-219 Transformation of a 1-Phase Short-Circuit Current

The changed measurand mapping also leads to a different impedance mapping. Figure 6-220 and Figure 6-221 show, for example, for a 2-phase or 3-phase short circuit on the star side, the resulting phasors on the delta side. To simplify it, the transformer ratio was assumed to be 1.

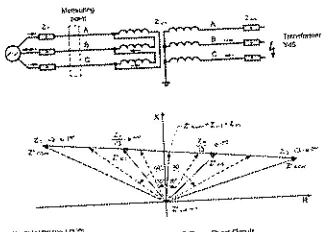


Figure 6-220 Impedance Measurement with a 2-Phase Short Circuit

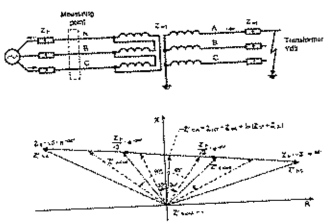


Figure 6-221 Impedance Measurement with a 3-Phase Short Circuit

With a 2-phase short circuit, the phase-to-ground impedance of the phase corresponds to the double phase current of the actual fault impedance via the transformer. The impedance is correctly measured. All other impedances are measured as considerably larger. Subtracting the currents results in an infinite impedance measured value for the C-A loop.

A 1-phase ground fault results in the smallest impedance value based on the calculation with phase-to-phase voltages (in the example, C-A). Because the zero-sequence system cannot be transferred via a star-delta transformer, an impedance is measured that is too large by the amount of the zero-sequence impedances (transformer, line). The actual fault location is seen as being further away.

With a 3-phase short circuit, the impedance measurement for all measuring loops is correct.

The following table summarizes the results of the impedance measurement for a star-delta transformer.

Table 6-7 Fault Mapping and Measuring Errors during the Impedance Measurement of a Star-Delta Transformer

Power System Fault on the Star Side	Fault Mapping on the Delta Side	Correct Impedance Loop	Measuring Error
3-phase short circuit	3-phase short circuit	Phase-to-ground and phase-to-phase loop	Correct measurement
2-phase short circuit	3-phase short circuit, different fault current distribution	Phase-to-ground loop with largest fault current	Correct measurement
1-phase ground fault	2-phase short circuit	Phase-to-phase loop, but with measuring error	Impedance measured too large by the amount of the zero-sequence impedance (ZL, ZT)

Logic of the Function

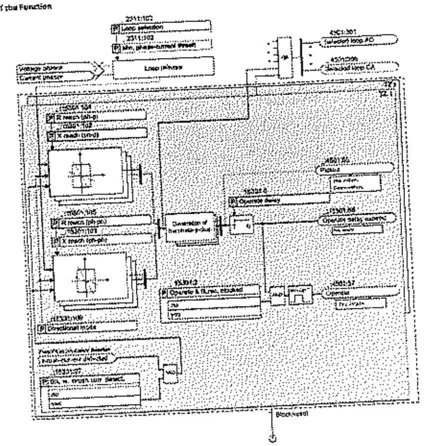


Figure 6-222 Logic Diagram for Impedance Protection

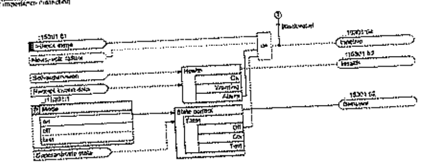


Figure 6-223 Logic Diagram for Impedance Protection (Continued)

Loop Selection

The function Impedance protection can be used in electrical power systems and plants with different neutral points. With the Loop selection parameter, you control which parameters influence the loop release.

In power systems with effective neutral point grounding – solidly or low-impedance grounded neutral point – all impedance loops (phase-to-ground and phase-to-phase loops) can work parallel to each other. When all loops are working parallel the loop release are controlled by the parameter Min. phase-current thresh (see following figure).

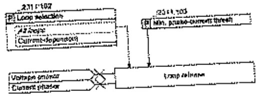


Figure 6-224 Effective Parameter for Loop Release for All Loops

In electrical power systems with a non-effective neutral point grounding – isolated, resonant-grounded or high-impedance grounded neutral point – the control for the loop selection is necessary to avoid an overfunction, for example, a ground fault. The loop selection is controlled by the Current-dependent parameter. The following figure shows an example which parameter controls the loop selection:

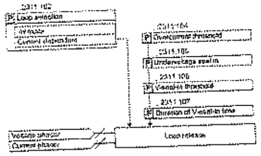


Figure 6-225 Effective Parameter in Current-Dependent Loop Release

In case of a ground fault the voltage collapses – ideally to 0 – and the phase-to-ground loop measures either a small impedance or 0 Ω. The phase-selective overcurrent detection releases the loops (parameter Overcurrent threshold). The undervoltage seal-in (parameter Undervoltage seal-in) keeps the overcurrent reset. The undervoltage seal-in is necessary for use in power plants when an exciting transformer is connected to the generator bus. During a near short circuit the excitation voltage collapses and results in a decreased synchronous generated voltage. Thereby the fault current sinks below the rated current and thereby the current threshold value (parameter Overcurrent threshold). The parameter V-seal-in threshold monitors the positive sequence voltage. The undervoltage seal-in drops out when the threshold value V-seal-in threshold is topped or the undervoltage seal-in time (parameter Duration of V-seal-in time) runs out.

The following rules apply for loop selection.

- In the event of 1-phase pickup, an associated phase-to-ground loop is used.
- In the event of 2-phase pickup, an associated phase-to-phase loop with the applicable phase-to-phase voltage is used for the impedance calculation.
- In the event of a 3-phase pickup, the loop selection is dependent on the ratio of the current amplitudes of the phases to one another.

The following table shows the measuring loop selection:

Pickup		Measuring Loops	
1-phase	A B C	Phase-to-ground	A-gnd B-gnd C-gnd
2-phase	A, B B, C C, A	Phase-to-phase	A-B B-C C-A
3-phase with unequal phase current amplitudes	A, 2 · B, C A, 2 · B, C A, 2 · B, C	If the current in one phase is double the size, the phase-to-ground loops are measured.	B-gnd C-gnd A-gnd
	(A, B) = 2 · C (B, C) = 2 · A (C, A) = 2 · B	If the current in two phases is double the size, the phase-to-phase loops are measured	A-B B-C C-A

Pickup		Measuring Loops	
3-phase with equal amplitudes	A, B, C	When all voltages are almost equal, the phase-to-phase loops are measured. All 3 loops are released.	A-B B-C C-A

Impedance Measurement

From the sampled values of the phase currents and the phase-to-ground voltages, the fundamental phasors are determined per period using an FIR filter (FIR = Finite Impulse Response). The impedances are calculated from the fundamental phasors. By using the frequency-tracking sampled values, the impedance is measured using another frequency range. This is advantageous for island networks or black-start power plants, for example, for start-up processes.

There is an impedance measuring element available for each of the 6 possible phase loops A-gnd, B-gnd, C-gnd, A-B, B-C, C-A. If another fault occurs during analysis, the impedances are calculated using the current cyclical measurands. The analysis thus always works with the measurands of the current fault condition.

The impedance for phase-to-phase loops is calculated as follows:

$$\underline{Z}_{ph-ph} = \frac{\underline{V}_{phx-phy}}{\underline{I}_{phx} - \underline{I}_{phy}}$$

The impedance of phase-to-ground loops is calculated as follows:

$$\underline{Z}_{ph-gnd} = \frac{\underline{V}_{phx}}{\underline{I}_{phx}}$$

Mode of Operation

If the phase currents exceed the set Imax. phase-current thresh., all released impedance loops are calculated.

To release phase-to-ground loops, it is sufficient if the corresponding phase current exceeds the Imax. phase-current thresh.. For phase-to-phase loops, both phase currents and the loop current must exceed the Imax. phase-current thresh..

There is no special ground-fault detection, such as distance protection for lines.

If the released impedance loop(s) lie in one zone, the impedance protection function generates a pickup indication with loop information. At the same time, a pickup indication in the picked up zone occurs with identification of the relevant phase and direction. The direction is subsequently determined for all picked up impedance loops and the associated time delay started. The output logic processes the pickup and trip signals of the zones and forms the pickup and trip signals of the function.

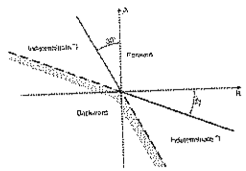
Direction Determination

The direction is determined either using a stored prefault voltage or negative-sequence system variables. If the measured negative-sequence voltage and the negative-sequence current exceed 10 % of the rated values of the device, the variables of the negative-sequence system are used exclusively. For the direction decision, the angle between the negative-sequence current I_2 and the negative-sequence voltage V_2 is evaluated.

Figure 6-226 shows the defined directional areas on impedance level.

For 3-phase symmetrical short circuits, there is no negative-sequence system. In this case, the memory voltage is used. If the memory voltage is not available either, for example when switching onto a fault, all zones – regardless of their parameterized direction – pick up and generate an operate indication after the time delay has expired.

Optionally, you can link the impedance protection function with the Instantaneous tripping at switch onto fault function (see chapter 6.13.4 Application and Setting Notes). This enables the selected impedance protection zones to trip without delay.



*) also valid for non-directional

Figure 6-226 Direction Characteristic Curve in the R-X Diagram

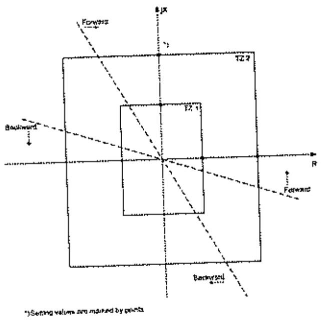
Inrush-Current Detection

If the device is equipped with the Inrush-current detection function, you can stabilize the zones against tripping due to transformer inrush currents.

Impedance Polygon

The quadrilateral operate curve (impedance polygon) of the zone is a rectangle in the R-X plane. The polygon is defined by the parameters X reach (ph-g), X reach (ph-ph), R reach (ph-g), and R reach (ph-ph) and the Directional mode. This means that, in special situations, a different setting is possible for phase-to-phase and phase-to-ground loops.

To stabilize the polygon limits, the characteristics have a hysteresis of 5 %. If the fault impedance lies within a polygon, the limits are increased by 5 % in all directions. The following figure shows an example with 2 non-directional zones.



*) Setting values are marked by points

Figure 6-227 Operate Curve with Quadrilateral Characteristic

6.13.4 Application and Setting Notes

Sample Configuration

The following figure is an example of how the impedance protection function is used at a feeder point in a medium-voltage power system.

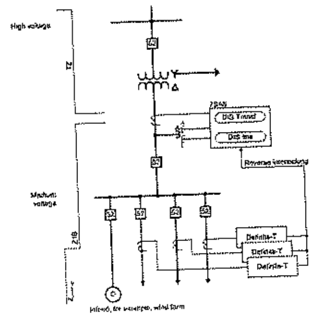


Figure 6-228 Example of a Network Protection Application

The medium-voltage power system is fed on the high-voltage side with a YNd5 transformer. In addition, there is an infeed that enables energy recovery to faults occurring on the high-voltage side.

The protection device installed on the delta side of the transformer functions as distance protection, which is the back-up protection for the medium-voltage power system.

In addition to distance protection, the protection device on the delta side functions as impedance protection, which looks in the transformer direction. The power system on the high-voltage side is a meshed system and also contains distance protection devices.

In the following, you can find recommendations for the protection setting values and a view of the setting problems. Figure 6-229 shows a possible setting approach.

Zone TZ 1 should be coordinated with the protection system and delayed by approx. 100 ms. The delay makes preferred tripping possible due to the differential protection and a dropout of the zone.

Zone TZ 2 is intended as a directional reserve stage, whose time must, without fail, be coordinated with the protection system. At the same time, the stage can be used if, when switching the transformer on, it switches onto a fault.

As a change, the function Instantaneous tripping at switch onto fault must be present and set accordingly (see functional description in chapter 6.43 Instantaneous Tripping at Switch onto Fault).

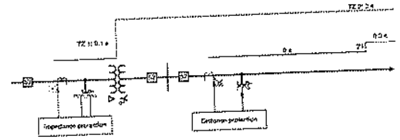


Figure 6-229 System Configuration and Possible Time Grading

For the example, the following data apply:

Table 6-8 Data for Sample Calculations

Transformer	Vector group:		YNd5
	Rated voltages:	Upper-voltage side	$V_{rated,UV}$ = 230 kV
		Undervoltage side	$V_{rated,US}$ = 20 kV
	Rated power:		S_{rated} = 50 MVA
	Short-circuit voltage:		V_{sc} = 12 %
Overhead line	Reactance per unit length:		X' = 0.3 Ω/km
	Length up to Z_{1}:		L = 50 km
Transducer	Voltage transformer:		20 kV/√3 /100 V/√3 / 100V/3
	Current transformer, undervoltage side:		1500 A/1 A

The primary side reactances are calculated as follows:

Transformer:

$$X_{Tr} = \frac{V_{sc} \cdot V^2_{rated}}{100\,\% \cdot S_{rated}} = \frac{12\,\% \cdot 20^2\,kV^2}{100\,\% \cdot 50\,MVA} = 0.96\,\Omega$$

Line (transferred to 20 kV):

$$X_{Ltr} = L \cdot X' \cdot \left(\frac{V_{rated,\,US}}{V_{rated,\,UV}}\right)^2 = 50\,km \cdot 0.3\,\frac{\Omega}{km} \cdot \left(\frac{20\,kV}{230\,kV}\right)^2 = 1.5\,\Omega \cdot 0.0756 = 0.013\,\Omega$$

The sample calculation clearly shows that the line reactance can be disregarded compared to transformer reactance due to the quadratic transformation.

To avoid overfunction, select the following setting values for the 1st Zone (TZ 1):

$X_1 = 0.9 \cdot X_{Tr} = 0.9 \cdot 0.96\,\Omega = 0.864\,\Omega$

For the 2nd Zone, select the double transformer impedance and set the delay time correspondingly high.

$X_2 = 2 \cdot X_{Tr} = 2 \cdot 0.96\,\Omega = 1.92\,\Omega$

With the selected setting, Zone TZ 1 does not protect the transformer completely, especially if you take into account the incorrect measurement for a 1-phase fault.

If you want to achieve a reliable reaching for all fault situations (see Table 6-7), the setting value must extend far beyond the transformer. One possible strategy for the time grading is a setting value of approx. 1.5 X_{Tr}.

You must guarantee the selectivity using the Time criterion. The following figure shows the time grading chart.

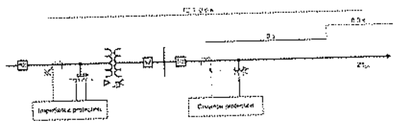


Figure 6-230 System Configuration and Possible Time Grading

The zone range in the R direction must take into account the fault resistance on the fault location. The fault resistance is added to the impedance of the fault loop as an additional effective resistance. This fault resistance is, for example, the arc resistance or the dissipation resistance of grounded phases. For the zone range in the R direction, you do not have to take the fault resistance on the upper-voltage side and the line resistance into account. These are also divided by the transformer-ratio quadratic and can be mostly disregarded. However, fault resistances on the upper-voltage side during high-current feed on the upper-voltage side also impact the reactance and resistance measurement on the undervoltage side. This impact is unavoidable and can result in a short circuit with fault resistance on the upper-voltage side not being detected by the undervoltage side until the high-current feed on the upper-voltage side is cleared. Do not set the reverse resistance any larger than necessary. The setting can be adjusted to the maximum feed in the direction of the line section to be protected, in other words, in the transformer direction. The setting value for the R range must be lower than the resistance under maximum load conditions (R_{Load}). For a sufficient distance to the load range, Siemens recommends a value of about 20 % to 50 % R_{Load}. This means an incorrect measurement is avoided by the apparent impedances (see Figure 6-206 and Figure 6-223).

Parameter: Loop selection

- Default setting (_:2311:102) Loop selection = All loops

You can use the Loop selection parameter to control the measuring-loop selection.

Parameter Value	Description
All loops	The function evaluates all 6 impedance loops. Siemens recommends using this setting value for electrical power systems or plants with an effective neutral-point grounding. For effective neutral-point grounding the neutral point is either fixed or low impedance grounded.
Current-dependent	Use this setting value for electrical power systems or plants with a non-effective neutral-point grounding. For non-effective neutral-point grounding the neutral point is isolated, grounded or high impedance grounded. Siemens recommends this setting value for generator-protection applications.

Parameter: Min. phase-current thresh

- Default setting (_:2311:103) Min. phase-current thresh = 0.200 A

You can use the Min. phase-current thresh parameter to set the lower pickup threshold for the current.
Set the parameter Min. phase-current thresh under the load current. A practical setting value is approximately 10 % to 20 % of the rated current of the protected object.

NOTE

Only if you set the Min. phase-current thresh parameter, the (_:2311:102) Loop selection = All loops parameter is visible.

Parameter: Overcurrent threshold

- Default setting (_:2311:104) Overcurrent threshold = 1.300 A

You can use the Overcurrent threshold parameter to set the lower pickup threshold for the overcurrent pickup.
Set the Overcurrent threshold parameter above the maximum possible load current. A practical setting value is approximately 1.2 to 1.4 times the generator rated current.

EXAMPLE:

The rated generator current is calculated as:

$$I_{rated,gen} = \frac{S_{rated}}{V_{rated}} = \frac{100\ MVA}{15.75\ kV \cdot \sqrt{3}} = 3666\ A$$

The primary setting value is calculated as follows:

$$I_{thresh,prim} = 1.4 \cdot I_{rated,gen} = 1.4 \cdot 3666\ A = 5132.4\ A$$

Taking into account the transformer ratios, the secondary setting value is calculated as follows:

$$I_{thresh,sec} = \frac{I_{thresh,prim}}{Ratio_{CT}} = \frac{5132.4\ A}{1000\ A/1\ A} = 1.283\ A$$

Parameter: Undervoltage seal in

- Default setting (_:2311:105) Undervoltage seal in = no

You can use the Undervoltage seal in parameter to specify whether you would like to maintain pickup from undervoltage.

Parameter Value	Description
no	If the fault current, during the entire fault duration, is above the setting value of the Overcurrent threshold parameter, then keep the default setting.
yes	Siemens recommends using this setting value for generator-protection applications, if during static excitation the exciting transformer is connected to the generator bus. In this situation the excitation voltage short is interrupted, thereby reducing the synchronous generated voltage; the fault current can sink after an extended period of time after the fault occurred below the generator rated current. If a fault occurs the fault current is noticeably greater than the rated current. The undervoltage seal-in maintains the pickup. When selecting this setting value, the following parameters are visible: • (_:2311:106) V-seal-in threshold • (_:2311:107) Duration of V-seal-in time

Parameter: V seal-in threshold

- Default setting (_:2311:106) V-seal-in threshold = 46.200 V

You can use the V-seal-in threshold parameter to set the lower pickup threshold for the undervoltage seal-in.
80 % of the generator rated voltage is a typical setting value. As the voltage transformers are precisely adapted to the object rated voltage, you can set 80 % of the secondary rated voltage. The parameter V-seal-in threshold evaluates the positive-sequence voltage. With a secondary rated voltage $V_{rated,sec}$ = 100 V, the setting value is determined as follows:

$$0.8 \cdot \frac{V_{rated,sec}}{\sqrt{3}} = 0.8 \cdot \frac{100\ V}{\sqrt{3}} = 46.2\ V$$

Parameter: Duration of V-seal-in time

- Default setting (_:2311:107) Duration of V-seal-in time = 4.00 s

You can use the Duration of V-seal-in time parameter to set how long the pickup must persist. If the Duration of V-seal-in time is exceeded, the pickup drops off. If, before the end of the Duration of V-seal-in time, the fault is cleared, the Undervoltage seal in drops off. If, before the end of the Duration of V-seal-in time the voltage setting V-seal-in threshold is exceeded again the Undervoltage seal in also drops.
Set the Duration of V-seal-in time above the maximum Operate delay. The default setting 4 s is a practicable value.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:15301:27) Blk. w. inrush curr. detect. = no

The parameter is only visible when the Inrush-current detection function is present in the application. Use the parameter to define whether the zone is blocked or not during transformer inrush-current detection.

Parameter: X reach (ph-g)

- Default setting (_:15301:102) X reach (ph-g) = 2.500 Ω

You can use the X reach (ph-g) parameter to set the polygon limit in the X direction for phase-to-ground impedance loops. Determine the setting value for the specific application.
If the impedance protection has to be measured well beyond the transformer into the upstream power system, Siemens recommends, as a setting value for the X reach (ph-g), approx. 1.5 times the transformer reactance. Adjust the associated delay time high enough so that short circuits downstream from the transformer can be initially cleared selectively.

EXAMPLE:

For the calculation, the data from Table 6-8 apply.
X range = 150 %
The primary setting value is calculated as follows:
X_{prim} = 150 %/100 % · Z_{sc} = 1.5 · 0.96 Ω = 1.44 Ω (primary)
Taking into account the transformer ratios, the secondary setting value is calculated as follows:

$$X_{sec} = \frac{I_{prim}/I_{sec}}{V_{prim}/V_{sec}} \cdot X_{prim} = \frac{1500\ A/1\ A}{20\ kV/100\ V} \cdot 1.44\ \Omega = 7.5 \cdot 1.44\ \Omega = 10.8\ \Omega$$

Parameter: X reach (ph-ph)

- Default setting (_:15301:103) X reach (ph-ph) = 2.500 Ω

You can use the X reach (ph-ph) parameter to set the polygon limit in the X direction for phase-to-phase impedance loops. Determine the setting value for the specific application.
If the impedance protection has to be measured well beyond the transformer into the upstream power system, Siemens recommends, as a setting value for the X reach (ph-ph), approx. 1.5 times the transformer reactance. Adjust the associated delay time high enough so that short circuits downstream from the transformer can be initially cleared selectively.
Because the phase-to-phase loop applies both to a 3-phase short circuit as well as to a 1-phase short circuit, the 3-phase short circuit is taken as the basis.
You can estimate the range for 1-phase short circuits by taking into account the zero-sequence impedance (reactance). The following applies:
$Z_{sc} = (Z_{+1} + 0.5 \cdot Z_0)$
For star-delta transformers, the zero-sequence impedance amounts to approx. $0.8 \cdot Z_{sc}$. This results in the following impedance measured value:
$Z_{sc} = (Z_{sc} + 0.5 \cdot Z_0) = (Z_{sc} + 0.5 \cdot 0.8 \cdot Z_{sc}) = 1.4\ Z_{sc}$
With a time grading of 1.5 Z_{sc}, measure the entire transformer winding for a 1-phase ground fault.
In the example, the same setting values apply for the phase-to-phase loops as for the phase-to-ground loops.

Parameter: R reach (ph-g)

- Default setting (_:15301:104) R reach (ph-g) = 2.500 Ω

You can use the R reach (ph-g) parameter to set the polygon limit in the R direction for phase-to-ground loops. For phase-to-ground faults, the fault resistance can be greater than that of phase-to-phase faults.

EXAMPLE:

For the calculation, the data from Table 6-8 apply.
The rated transformer current is assumed as the rated load current. The current is 1443 A on the 20 kV side.

$$Z_{Load} = \frac{0.9 \cdot V_{rated}}{1.1 \cdot \sqrt{3} \cdot I_{rated,load}} = \frac{0.9 \cdot 20\ kV}{1.1 \cdot \sqrt{3} \cdot 1443\ A} = 7.27\ \Omega$$

For the R reach, 20 % · Z_{Load} is specified. This means the primary setting value of the R reach (ph-g) parameter is calculated as follows:
R reach (ph-g) = 0.2 · 7.27 Ω = 1.45 Ω
This value corresponds to approx. the X value so that you can select, as a practical setting, R range = X range.
Taking into account the transformer ratios, the secondary setting value is calculated as follows:

$$R_{sec} = \frac{I_{prim}/I_{sec}}{V_{prim}/V_{sec}} \cdot X_{prim} = \frac{1500\ A/1\ A}{20\ kV/100\ V} \cdot 1.45\ \Omega = 7.5 \cdot 1.45\ \Omega = 10.9\ \Omega$$

Parameter: R reach (ph-ph)

- Default setting (_:15301:105) R reach (ph-ph) = 1.250 Ω

You can use the R reach (ph-ph) parameter to set the polygon limits in the R direction for phase-to-phase loops.

EXAMPLE:

For the calculation, the data from Table 6-8 apply.
Set the range for phase-to-phase loops just like for phase-to-ground loops. This results in the following setting values:
R reach (ph-ph) = R reach (ph-g) = 1.45 Ω (primary)
R reach (ph-ph) = R reach (ph-g) = 10.9 Ω (secondary)

Parameter: Directional mode

- Default setting (_:15301:109) Directional mode = reverse

You can use the Directional mode parameter to specify whether the zone operates forward, reverse, or non-directional. Set the parameter Directional mode for the specific application.
If the impedance protection function is present in a power-system protection device, the directional mode is in the direction of the line forward. If you want to use the impedance zone as backup protection for a transformer, you have to set the parameter Directional mode = reverse.

Parameter: Operate delay

- Default setting (_:15301:6) Operate delay = 0.30 s

You can use the Operate delay parameter to set the grading time of the zone. Set the parameter Operate delay for the specific application.
Select the associated time stage for Zone Z2 so that it staggers the power-system protection devices of the following level. Therefore, check the grading times in the superposed power system as well as the range in the power system if 1.5 Z_{sc} is set.

6.13.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Loop selection		• All loops • Current-dependent	All loops
_:2311:103	General:Min. phase-current thresh	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:104	General:Overcurrent threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.300 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.500 A
_:2311:105	General:Undervoltage seal in		• no • yes	no
_:2311:106	General:V-seal-in threshold		0.300 V to 340.000 V	46.200 V
_:2311:107	General:Duration of V seal-in time		0.00 s to 60.00 s	4.00 s

Addr.	Parameter	C	Setting Options	Default Setting
Z2 1				
_:15301:1	Z2 1:Mode		• off • on • test	on
_:15301:2	Z2 1:Operate & flt.rec. blocked		• no • yes	no
_:15301:27	Z2 1:Blk. w. inrush curr. detect.		• no • yes	no
_:15301:102	Z2 1:X reach (ph-g)	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:15301:103	Z2 1:X reach (ph-ph)	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:15301:104	Z2 1:R reach (ph-g)	1 A	0.100 Ω to 600.000 Ω	2.500 Ω
		5 A	0.020 Ω to 120.000 Ω	0.500 Ω
_:15301:105	Z2 1:R reach (ph-ph)	1 A	0.100 Ω to 600.000 Ω	1.250 Ω
		5 A	0.020 Ω to 120.000 Ω	0.250 Ω
_:15301:109	Z2 1:Directional mode		• non-directional • forward • reverse	reverse
_:15301:6	Z2 1:Operate delay		0.00 s to 60.00 s; ∞	0.30 s

6.13.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:54	General:Inactive	SPS	O
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
_:4501:301	Group indicat.:Selected loop AG	ACD	O
_:4501:302	Group indicat.:Selected loop BG	ACD	O
_:4501:303	Group indicat.:Selected loop CG	ACD	O
_:4501:304	Group indicat.:Selected loop AB	ACD	O
_:4501:305	Group indicat.:Selected loop BC	ACD	O
_:4501:306	Group indicat.:Selected loop CA	ACD	O
Z2 1			
_:15301:81	Z2 1:>Block stage	SPS	I
_:15301:54	Z2 1:Inactive	SPS	O
_:15301:52	Z2 1:Behavior	ENS	O
_:15301:53	Z2 1:Health	ENS	O
_:15301:55	Z2 1:Pickup	ACD	O
_:15301:56	Z2 1:Operate delay expired	ACT	O
_:15301:57	Z2 1:Operate	ACT	O

ВЯРНО С ОРИГИНАЛА

6.14 Power-Swing Blocking

6.14.1 Overview of Functions

Power-swing blocking:

- Detects power swings
- Evaluates the impedances per phase accordingly
- Checks the impedance trajectory on a continual basis
- Reports the power swing detection per phase
- Blocks the selected zones of the distance protection in case of power swings
- Detects 1-phase, 2-phase, and 3-phase short circuits during a power swing and then cancels the blocking for the specific phase
- Works during a 1-pole dead time
- Activates only when the distance protection function is active
- Does not generate tripping of the out-of-step condition; a separate out-of-step protection function is available for this purpose

6.14.2 Structure of the Function

The Power-swing blocking function is a supplementary function to the distance protection. It only works if the distance-protection function is activated. If a power swing is detected, power swing blocking blocks the pickup and tripping through the distance protection. Each distance protection zone can be blocked separately.

The Power swing blocking function is included in a function group with at least 3 voltage inputs and current inputs. The process monitor delivers status information to the function regarding the protected object (open pole in particular).

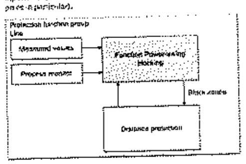


Figure 6-231 Power-Swing Blocking Works Together with the Distance-Protection Function

6.14.3 Function Description

Power-Swing Event

After dynamic events such as load jumps, short circuits, automatic reclosing functions, or switching operations, the generators in the installations may have to respond to the new power balance of the system. In case of power swings, the distance-protection function is fed with high compensating currents and – especially at the electrical center – low voltages (Figure 6-232). Low voltages combined with high currents

represent apparently small impedances that can lead to tripping by the distance protection. Power-swing blocking prevents tripping by the distance protection in case of power swings.

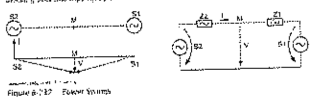


Figure 6-232 Power Swings

Power swings are 3-phase symmetrical events. As a rule, a certain symmetry of the measurands can be assumed. Power swings may also occur during unsymmetrical events, such as short circuits or during a 1-pole dead time. For this reason, power-swing detection is structured as one 3-measuring system. One measuring system is available for each phase, which warrants phase-selective power-swing detection. If short circuits occur, the power swing detected in the respective phase will be canceled, which enables the distance protection function to initiate selective tripping.

Functionality

In order to detect the power swing, the rate of change will be adjusted in the impedance phasor.

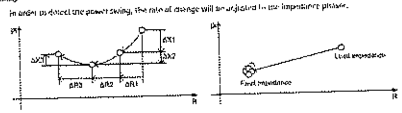


Figure 6-233 Impedance Vectors During a Power Swing and During a Short Circuit

In order to warrant all functions of the power-swing detection are stable and secure, without the risk of over function during a short circuit, the following measurement criteria are used:

- **Trajectory monotony:**
  During a power swing, the measured impedance indicates a directional path of movement. This path occurs precisely if within the measurement window one of the components ΔR and ΔX at the most indicates a change of direction. As a rule, if a short circuit occurs, it causes a directional change in ΔR as well as in ΔX within the measured value window.
- **Trajectory continuity:**
  The spacing of two consecutive impedance values will clearly indicate a change of ΔR or ΔX during a power swing. If a short circuit occurs, the impedance vector skips to the fault impedance and remains motionless.
- **Trajectory uniformity:**
  During a power swing the ratio between 2 consecutive changes of ΔR or ΔX do not exceed a threshold. As a rule, if a short circuit occurs, it will cause an erratic movement since the impedance phasor abruptly skips from load impedance to fault impedance.

If the impedance indicator enters the distance protection pickup range and the power-swing detection criteria are met, a power swing will be indicated. The pickup range is composed of the largest setting values for R and X in all active zones.

Figure 6-234 shows the logic of the power-swing blocking. The measurement takes place per phase. A power-swing detection signal will be transmitted only after the measured impedance is in the distance protection pickup range (_:102 Block. zones). The power-swing detection signal remains active until a short circuit

occurs, the power swing subsides, or the maximum blocking time has elapsed. You can use the binary input signal >Block function to block the power swing detection.

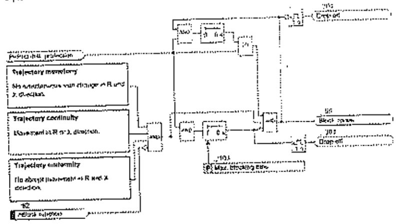


Figure 6-234 Power-Swing Blocking Logic

When using the Max. blocking time parameter, you can place a time limit on the blocking effect of the power-swing blockage. In this way, for instance, the power-swing blockage can be eliminated when using systems that are slowly drifting apart.

When the impedance enters the distance protection pickup range, the maximum blocking time will be started. When the impedance exits the pickup range while the maximum blocking time is running, the maximum blocking time will be reset.

Logic

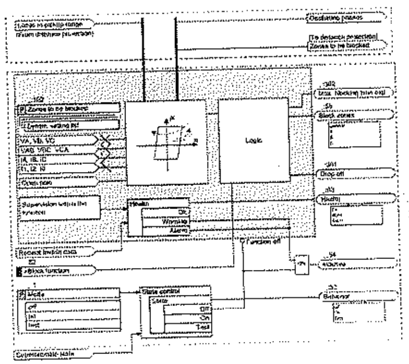


Figure 6-235 Functionality of Power-Swing Blocking

The distance protection delivers information about the loops contained in its zones to the power-swing blocking. If the power-swing blocking detects power swings in the activated loops, it delivers phase-selective information about the zones to be blocked to the distance protection. The actual blocking is carried out in the distance protection.

6.14.4 Application and Setting Notes

Selection of the Distance Zones to be Blocked

- Recommended setting value (_:102) Zones to be blocked = Zone X

Parameter Value	Description
Zones to be blocked	Via a parameter, the user can individually select each zone present in the distance protection function that is to be blocked during a power swing.

Maximum Blocking Time

- Default setting (_:103) Max. blocking time = ∞

When using the Max. blocking time parameter, you can limit the maximum blocking time of the distance protection during the power swing. In this way, for instance, the power-swing blockage can be eliminated when using networks that are slowly drifting apart.

For tripping during an asynchronous long-lasting power swings, Max. blocking time is not relevant. For this application, use the function **Out-of-step protection**.

If there is no operational requirement with regards to a time limit of the power swing blocking, Siemens recommends the default setting = ∞ (= not in effect)

Further Application Notes

The following table provides application notes for the interaction with other internal or external functions.

Interaction with Other Functions	Note
Distance Protection	Distance protection delivers information about which impedance loops picked up. If power swings occur, pickup and tripping of the distance protection are blocked for the specific phases and zones. Power-swing blocking only works if the distance-protection function is activated.

6.14.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Power-Swing Blocking				
_:1	68 P.swing blk:Mode		• off • on • test	off
_:103	68 P.swing blk:Max. blocking time		0.00 s to 60.00 s; ∞	∞ s
_:102	68 P.swing blk:Zones to be blocked		Setting options depend on configuration	

6.14.6 Information List

No.	Information	Data Class (Type)	Type
68 P.swing blk			
_:82	68 P.swing blk:>Block function	SPS	I
_:54	68 P.swing blk:Inactive	SPS	O
_:52	68 P.swing blk:Behavior	ENS	O
_:53	68 P.swing blk:Health	ENS	O
_:56	68 P.swing blk:Block zones	ACD	O
_:301	68 P.swing blk:Drop off	SPS	O
_:302	68 P.swing blk:Max. blocking time exp.	SPS	O

6.15 External Trip Initiation 3-Pole

6.15.1 Overview of Functions

The External trip initiation function:

- Processes any signals from external protection or supervision devices
- Enables the integration of any signals from external protection equipment in the indication and tripping processing, for example from transient ground-fault relays or Buchholz protection
- Enables direct tripping of the circuit breaker in conjunction with busbar-protection applications
- Enables direct tripping of the circuit-breaker in the case of circuit-breaker failure at the other line end

6.15.2 Structure of the Function

The External trip initiation function contains one step. The External trip initiation function can be instantiated in DIGSI 5 multiple times.

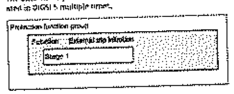


Figure 6-236 Structure/Embedding of the Function

6.15.3 Stage Description

Logic of the Stage

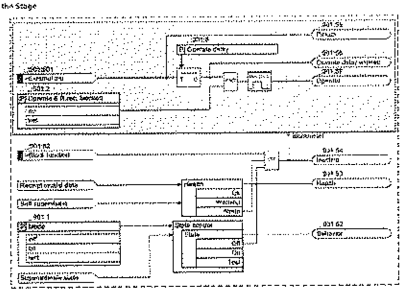


Figure 6-237 Logic Diagram for the External Trip Initiation Stage

Binary Input Signal >External Trip

The binary input signal >External trip starts the Pickup and the Operate delay.

Blocking the Stage

The stage can be switched to ineffective via a number of signals. If the stage is in the pickup state at the time of blocking, it will be immediately reset. However, the operate indication remains stopped for the minimum operating time (_:102) Minimum operate time.

6.15.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value (_:901:6) Operate delay = 0.05 s

The Operate delay parameter must be set for the specific application. After expiry of the Operate delay the time expiry and tripping are signaled. The duration of the indication signal as well as the adjustable minimum command time determine the signal duration of the Operate.

6.15.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:901:1	Stage 1:Mode		• off • on • test	off
_:901:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:901:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.05 s

6.15.6 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:901:81	Stage 1:>Block function	SPS	I
_:901:501	Stage 1:>External trip	SPS	I
_:901:54	Stage 1:Inactive	SPS	O
_:901:52	Stage 1:Behavior	ENS	O
_:901:53	Stage 1:Health	ENS	O
_:901:55	Stage 1:Pickup	ACD	O
_:901:56	Stage 1:Operate delay expired	ACT	O
_:901:57	Stage 1:Operate	ACT	O

6.16 Overcurrent Protection, Phases

6.16.1 Overview of Functions

The Overcurrent protection, phases function (ANSI 50/51):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.16.2 Structure of the Function

The Overcurrent protection, phases function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, phases – advanced (50/51 OC 3ph-A)**
- **Overcurrent protection, phases – basic (50/51 OC 3ph B)**

The Basic function type is provided for standard applications. The Advanced function type offers more functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the **Overcurrent protection, phase – advanced** function type, the following stages can be operated simultaneously:

- Maximum of 4 stages **Definite time-overcurrent protection – advanced**
- 2 stages **Inverse time-overcurrent protection – advanced**
- 2 stages **User-defined overcurrent protection characteristic curve**

In the **Overcurrent protection, phases – basic** function type, the following stages can be operated simultaneously:

- Maximum of 4 stages **Definite time-overcurrent protection – basic**
- 1 stage **Inverse time-overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping-delay characteristic, the stages are identical in structure.

The optional function block Filter offered in the advanced function allows to gain harmonics or to compensate the amplitude attenuation for the RMS value.

The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage selective indications:

- **Pickup**
- **Operate**

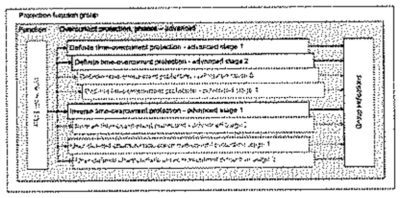


Figure 6-238 Structure/Embedding of the Function Overcurrent Protection, Phases – Advanced

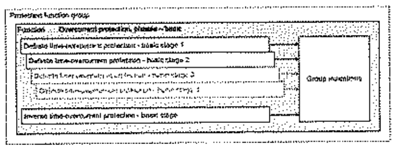


Figure 6-239 Structure/Embedding of the Function Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and time delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal. This functionality is only available in the Advanced function type.

- Cold-load pickup detection
- Binary input signal

If the device is equipped with the inrush-current detection function, the stages can be stabilized against tripping due to transformer inrush currents.

6.16.3 Filter for RMS Value Gain

6.16.3.1 Description

The function block Filter can be used to adapt the RMS value for 2 reasons:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter.
- To only compensate the amplitude attenuation of higher frequencies due to the anti-aliasing filter

The filter gain (amplitude response) is realized by a 9 order FIR filter.

Logic

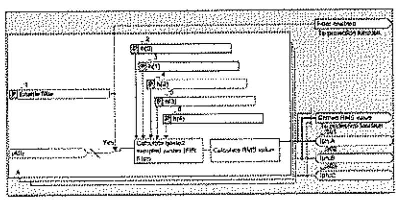


Figure 6-240 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards, the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the values of the respective parameters h(0), h(1), h(2), h(3), and h(4).

> **NOTE**
>
> A FIR-filter configuration tool is provided as an auxiliary PC tool. With the PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block Filter is instantiated and the parameter Enable filter is set as yes. Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Gained RMS measured value of current A	kA	A	Parameter Rated current
Iph:B	Gained RMS measured value of current B	kA	A	Parameter Rated current

Values	Description	Primary	Secondary	% Referenced to
Iph:C	Gained RMS measured value of current C	kA	A	Parameter Rated current

You can find the parameter Rated current in the **FG General** of function groups where the **Overcurrent protection, phases – advanced** function is used.

If the parameter Enable filter is set to no, the functional measured values are shown as ---.

6.16.3.2 Application and Setting Notes

Parameter: Enable filter

- Default setting (_:1) Enable filter = no.

With the parameter Enable filter, you set whether the Filter is enabled.

Parameter Value	Description
yes	If gained RMS values should be used in one of the protection stages, set parameter Enable filter = yes.
no	If no gained RMS values are needed, set the parameter Enable filter = no.

Parameter: h(0), h(1), h(2), h(3), h(4)

- Default setting (_:2) h(0) = 0.000
- Default setting (_:3) h(1) = 0.000
- Default setting (_:4) h(2) = 0.000
- Default setting (_:5) h(3) = 0.000
- Default setting (_:6) h(4) = 1.000

With the default value of the coefficients, the filter has no effect and no gain is applied.

If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically taken into account and compensated by the filter.

To only compensate the attenuation of higher frequencies by the device, set the following coefficients to the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

720

6.16.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filt.Ch.Fil				
_:1	Filter:Enable filter		• no • yes	no
_:2	Filter:h(0)		-100.000 to 100.000	0.000
_:3	Filter:h(1)		-100.000 to 100.000	0.000
_:4	Filter:h(2)		-100.000 to 100.000	0.000
_:5	Filter:h(3)		-100.000 to 100.000	0.000
_:6	Filter:h(4)		-100.000 to 100.000	1.000

6.16.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:phs A	MV	O
_:302	Filter:phs B	MV	O
_:303	Filter:phs C	MV	O

6.16.4 Stage with Definite-Time Characteristic Curve

6.16.4.1 Description

Logic of the Basic Stage

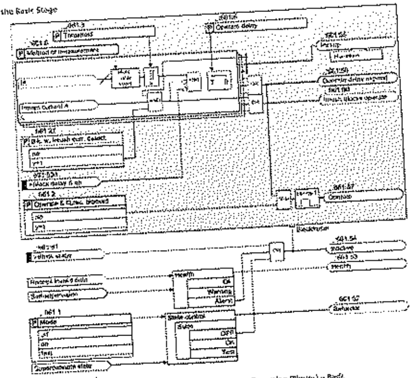


Figure 6-241 Logic Diagram of the Definite Time-Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage

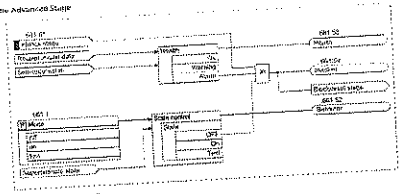


Figure 6-242 Logic Diagram of the Stage Control

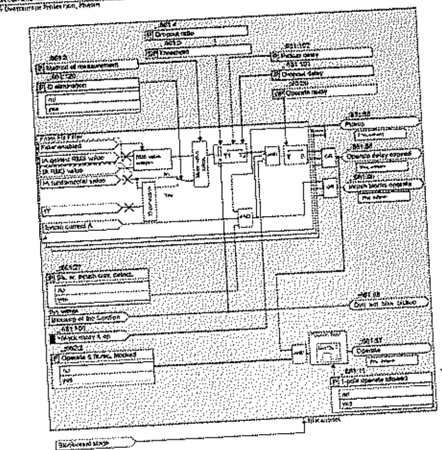


Figure 6-243 Logic Diagram of the Definite Time-Overcurrent Protection (Phases) – Advanced

Method of measurement (Basic and Advanced Stage)

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

RMS Value Selection (Advanced Stage)

If RMS value is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block Filter

If the function block Filter is configured and if you have enabled the filter, the gained RMS value is automatically used.

> **NOTE**
> When the function block Filter is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the phase-to-phase faults on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection application on one transformer. In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.

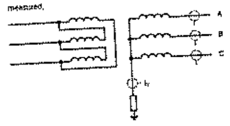


Figure 6-244 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the Transformer neutral point function group. Connect the function group Transformer neutral point to the function group Transformer side. In the function Overcurrent protection, phases operates only in the Transformer side function group.

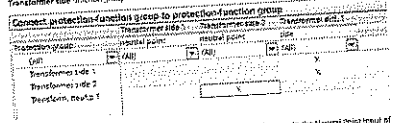


Figure 6-245 Connection of the Transformer Neutral Point Function Group with the Neutral Point Input of the Transformer Side Function Group

In case of an I0 elimination, the following calculations result:

$I_{A-I0} = I_A - 1/3 I_Y$

$I_{B-I0} = I_B - 1/3 I_Y$

$I_{C-I0} = I_C - 1/3 I_Y$

The phase current I_{phs-I0} is necessary for the following protection process.

If the Method of measurement parameter is set to fundamental comp., the I0 elimination is applied.

The currents I_{phs-I0} are available as functional values.

Pickup delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay is generated. If the threshold remains exceeded during the pickup delay time, the pickup signal is generated.

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage from an external or internal source
- Via the functionality of the dynamic settings (only available in the Advanced function type, see subtitle Influence of other functions via dynamic settings and chapter 6.16.8.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.16.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.16.8.1 Description.

6.16.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:661:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value parameter value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.

Parameter Value	Description
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the Threshold value of the stage to less than $0.1 I_{rated}$.

Parameter: Threshold, Operate delay

- Default setting (_:661:3) Threshold = 1.500 A (for the 1st stage)
- Default setting (_:661:6) Operate delay = 0.30 s (for the 1st stage)

Set the Threshold and Operate delay parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite time-overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since the overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Therefore, set the Threshold parameter for lines to approx. 10 %, for transformers and motors to approx. 20% above the maximum load that is expected.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power

P_{max} = 120 MVA

Correspondingly

I_{max} = 630 A

Current transformer = 600 A/5 A

Safety factor = 1.1

Settings in primary and secondary values result in the setting values:

Threshold value 1st stage (primary) = 1.1 · 630 A = 693 A

Threshold value 1st stage (secondary) $= 1.1 \cdot \frac{630\ A}{600\ A} \cdot 5\ A = 5.8\ A$

The Operate delay to be set is derived from the time grading schedule that has been prepared for the system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the Threshold parameter to ensure that the stage does not pick up in case of a short circuit at the end of the line.

Set the Operate delay parameter to 0 or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length) = 60 km

Z_1/s = 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: Z_0/Z_1 = 4

Short-circuit power at the beginning of the line:

S_k'' = 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: Z_{0S}/Z_{1S} = 2

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_S:

Z_L = 0.46 Ω/km · 60 km = 27.6 Ω

$$Z_S = \frac{110\ kV^2}{2500\ MVA} = 4.84\ \Omega$$

The 3-phase short-circuit current at the end of the line is $I_{k\,end}$:

$$I_{k\,end} = \frac{1.1 \cdot U_{rated}}{\sqrt{3} \cdot (Z_S + Z_L)} = \frac{1.1 \cdot 110\ kV}{\sqrt{3} \cdot (4.84\ \Omega + 27.6\ \Omega)} = 2150\ A$$

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

Threshold value 2nd stage (primary) = 1.1 · 2150 A = 2365 A

Threshold value 2nd stage (secondary) $= 1.1 \cdot \frac{2150\ A}{600\ A} \cdot 5\ A = 19.7\ A$

If short-circuit currents exceed 2365 A (primary) or 19.7 A (secondary), there is a short circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: the amounts in the calculation example are accurate enough for overhead lines. If the source impedance and line impedance have different angles, you have to use complex numbers to calculate the Threshold.

Parameter: I0 elimination

- Default setting (_:661:120) I0 elimination = no

This parameter is not visible in the basic stage.

The I0 elimination of phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the phase-to-phase fault on the transformer low-voltage side. The following conditions must be fulfilled:

- The transformer neutral point current I_N is measured and is available for the protection function group.
- The parameter Method of measurement is set to fundamental comp.

With the I0 elimination parameter, you can switch the I0 elimination function on or off.

Parameter: Pickup delay

- Default setting (_:661:102) Pickup delay = 0.00 s

This parameter is not visible in the basic stage.

For special applications, it is desirable that a short exceeding of the current threshold does not lead to the pickup of the stage and start fault logging and recording. If this stage is used as a thermal overload function that is considered a special application.

When using the Pickup delay parameter, a time interval is defined during which a pickup is not triggered if the current threshold is exceeded.

For all short-circuit protection applications, this value is not set at all (null).

Parameter: Dropout delay

- Recommended setting value (_:661:101) Dropout delay = 0.00 s

This parameter is not visible in the basic stage.

Siemens recommends to use the default setting 0 since the dropout of a protection stage must be done as fast as possible.

You can use the Dropout delay parameter ≠ 0 ms to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: Dropout ratio

- Recommended setting value (_:661:4) Dropout ratio = 0.95

This parameter is not visible in the basic stage.

The recommended set value of 0.95 is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter Dropout ratio can be reduced, for example, to 0.98. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter Dropout ratio. This avoids chattering of the tripping stage.

Parameter: 1-pole operate allowed

- Default setting (_:661:11) 1-pole operate allowed = no

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (contained in the tripping logic of the function group Circuit breaker) is always 3-pole because the device does not support phase-selective tripping.

6.16.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:661:1	Definite-T 1:Mode		• off • on • test	off
_:661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:661:11	Definite-T 1:1-pole operate allowed		• no • yes	no
_:661:26	Definite-T 1:Dynamic settings		• no • yes	no
_:661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.

Addr.	Parameter	C	Setting Options	Default Setting
_:661:120	Definite-T 1:I0 elimination		• no • yes	no
_:661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:661:102	Definite-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:661:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n-rdy				
_:661:28	Definite-T 1:Effect. by AR off/n-ready		• no • yes	no
_:661:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:661:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:661:36	Definite-T 1:Stage blocked		• no • yes	no
_:661:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:661:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:661:37	Definite-T 1:Stage blocked		• no • yes	no
_:661:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:661:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:661:38	Definite-T 1:Stage blocked		• no • yes	no
_:661:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:661:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:661:39	Definite-T 1:Stage blocked		• no • yes	no
_:661:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:661:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:661:40	Definite-T 1:Stage blocked		• no • yes	no
_:661:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: Bin.input				
_:661:34	Definite-T 1:Effected by binary input		• no • yes	no
_:661:41	Definite-T 1:Stage blocked		• no • yes	no
_:661:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.16.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation cold-load pickup	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:661:81	Definite-T 1:>Block stage	SPS	I
_:661:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:661:500	Definite-T 1:>Block delay & op.	SPS	I
_:661:54	Definite-T 1:Inactive	SPS	O
_:661:52	Definite-T 1:Behavior	ENS	O
_:661:53	Definite-T 1:Health	ENS	O
_:661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:661:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:661:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:661:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:661:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:661:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:661:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:661:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:661:55	Definite-T 1:Pickup	ACD	O
_:661:56	Definite-T 1:Operate delay expired	ACT	O
_:661:57	Definite-T 1:Operate	ACT	O
_:661:302	Definite-T 1:[illegible]	[illegible]	O
Definite-T 2			
_:662:81	Definite-T 2:>Block stage	SPS	I
_:662:84	Definite-T 2:>Activ. dyn. settings	SPS	I
_:662:500	Definite-T 2:>Block delay & op.	SPS	I
_:662:54	Definite-T 2:Inactive	SPS	O
_:662:52	Definite-T 2:Behavior	ENS	O
_:662:53	Definite-T 2:Health	ENS	O
_:662:60	Definite-T 2:Inrush blocks operate	ACT	O
_:662:62	Definite-T 2:Dyn.set. AR cycle1act.	SPS	O
_:662:63	Definite-T 2:Dyn.set. AR cycle2act.	SPS	O
_:662:64	Definite-T 2:Dyn.set. AR cycle3act.	SPS	O
_:662:65	Definite-T 2:Dyn.set. ARcycl.>3act	SPS	O
_:662:66	Definite-T 2:Dyn.set. CLP active	SPS	O
_:662:67	Definite-T 2:Dyn.set. BI active	SPS	O
_:662:68	Definite-T 2:Dyn. set. blks. pickup	SPS	O
_:662:55	Definite-T 2:Pickup	ACD	O
_:662:56	Definite-T 2:Operate delay expired	ACT	O
_:662:57	Definite-T 2:Operate	ACT	O
_:662:302	Definite-T 2:[illegible]	[illegible]	O

6.16.5 Stage with Inverse-Time Characteristic Curve

6.16.5.1 Description

Logic of the Basic Stage

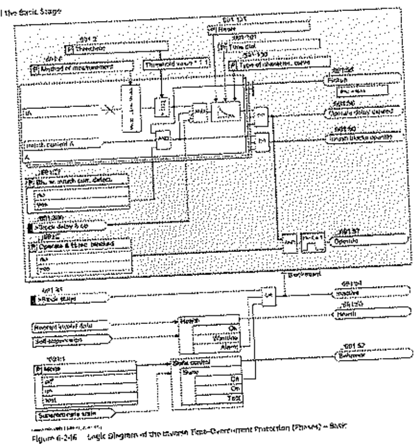


Figure 6-246 Logic Diagram of the Inverse-Time Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage

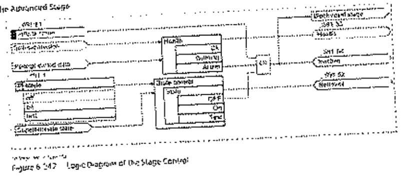


Figure 6-247 Logic Diagram of the Stage Control

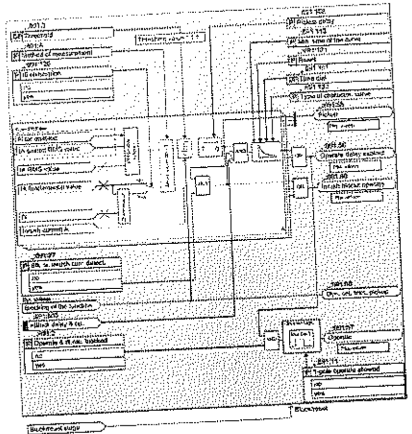


Figure 6-248 Logic Diagram of the Inverse-Time Overcurrent Protection (Phases) – Advanced

RMS-Value Selection (Advanced Stage)

If RMS value is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block Filter

If the function block Filter is configured and if you set parameter _:2311:[?]_OCP_Inverse time_Advanced_1_en_US, have enabled the filter, the gained RMS value is automatically used.

> **NOTE**
> When the function block Filter is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.

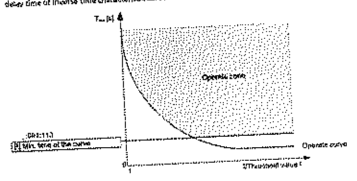


Figure 6-249 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Method of Measurement (Basic and Advanced Stage)

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the phase-to-phase fault on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection applications on the transformer. In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.

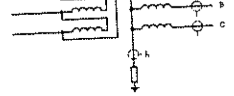


Figure 6-250 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the Transformer neutral point function group. Connect the function group Transformer neutral point to the function group Transformer side. In the function Overcurrent protection, phases operates with in the Transformer side function group.

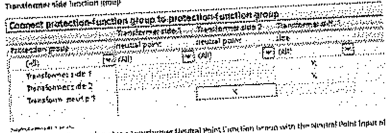


Figure 6-251 Connection of the Transformer Neutral Point Function Group with the Neutral Point Input of the Transformer Side Function Group

In case of an I0 elimination, the following calculations must be considered:

$I_{A\text{-}elim} = I_A - 1/3\, I_Y$

$I_{B\text{-}elim} = I_B - 1/3\, I_Y$

$I_{C\text{-}elim} = I_C - 1/3\, I_Y$

The phase current $I_{phase\text{-}elim}$ is necessary for the following protection process.

If the Method of measurement parameter is set to fundamental comp., the I0 elimination is operating.

The currents $I_{x\text{-}elim}$ are available as functional values.

Pickup Delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay starts. If the threshold is exceeded during the pickup delay time, the pickup signal is generated.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage from an external or internal source
- Via the functionality of the dynamic settings (only available in the Advanced function type, see subtitle Influence of other functions via dynamic settings and chapter 6.16.8.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.16.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.16.8.1 Description.

6.16.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:691:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than $0.1\, I_{rated,sec}$.

Parameter: Type of character. curve

- Default setting (_:691:130) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application. For more information about the parameter Type of character. curve, refer to chapter 11.15.1 Stage with Inverse-Time Characteristic Curve.

Parameter: Min. time of the curve

- Default setting (_:691:113) Min. time of the curve = 0.00 s

This parameter is only available in the advanced stage.

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

ВЯРНО С ОРИГИНАЛА

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting (_:691:110) Additional time delay = 0.00 s

With the parameter Additional time delay, you define a definite time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, the parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: Threshold

- Default setting (_:691:3) Threshold = 1.500 A

Set the Threshold and Type of character. curve parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Set the Threshold parameter for lines to approx. 10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the Threshold.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power

P_{max} = 120 MVA

Correspondingly

I_{max} = 630 A

Current transformer = 600 A/5 A

Settings in primary and secondary values result in the setting values

Threshold value I> (primary) = 630 A

Threshold value I> (secondary) = $\frac{630\ A}{600\ A} \cdot 5\ A = 5.25\ A$

Parameter: I0 elimination

- Default setting (_:661:120) I0 elimination = no

This parameter is not visible in the basic stage.

The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the phase-to-phase faults on the low-voltage side of the transformer. The following conditions must be fulfilled:

- The transformer neutral point current I_N (measured) is available for the protection function group.
- The parameter Method of measurement is set to fundamental comp..

With the I0 elimination setting, you can switch the I0 elimination function on or off.

Parameter: Pickup delay

- Default setting (_:661:102) Pickup delay = 0.00 s

This parameter is not visible in the basic stage.

For special applications it is desirable if the current threshold is briefly exceeded, that this will not lead to the pickup of the stage and starts fault logging or recording. If the stage is used as a thermal overload function, that is considered a special application.

When using the Pickup delay parameter, a time interval is defined during which a pickup is not trigger if the current threshold is exceeded.

For all short-circuit protection applications, the value is 0.00 s and is considered as a default.

Parameter: Time dial

- Default setting (_:691:101) Time dial = 1.00

Use the Time dial parameter to displace the characteristic curve in the time direction.

The set value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter Time dial at 1 (default setting).

Parameter: Reset

- Default setting (_:691:131) Reset = disk emulation

You use the Reset parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: 1-pole operate allowed

- Default setting (_:691:11) 1-pole operate allowed = no

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group Circuit-breaker) is always 3-pole because the device does not support phase-selective tripping.

6.16.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:691:1	Inverse-T 1:Mode		• off • on • test	off
_:691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:691:11	Inverse-T 1:1-pole operate allowed		• no • yes	no
_:691:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:691:120	Inverse-T 1:I0 elimination		• no • yes	no
_:691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:102	Inverse-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:691:130	Inverse-T 1:Type of character. curve			
_:691:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:691:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:691:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:691:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:691:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:691:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:691:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:691:36	Inverse-T 1:Stage blocked		• no • yes	no
_:691:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A

Addr.	Parameter	C	Setting Options	Default Setting
_:691:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:691:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:691:37	Inverse-T 1:Stage blocked		• no • yes	no
_:691:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:691:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:691:38	Inverse-T 1:Stage blocked		• no • yes	no
_:691:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:691:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:691:39	Inverse-T 1:Stage blocked		• no • yes	no
_:691:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:691:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:691:40	Inverse-T 1:Stage blocked		• no • yes	no
_:691:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A

Addr.	Parameter	C	Setting Options	Default Setting
_:691:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: Bin. input				
_:691:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:691:41	Inverse-T 1:Stage blocked		• no • yes	no
_:691:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.16.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:Activation cold-load pickup	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:691:81	Inverse-T 1:>Block stage	SPS	I
_:691:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:691:54	Inverse-T 1:Inactive	SPS	O
_:691:52	Inverse-T 1:Behavior	ENS	O
_:691:53	Inverse-T 1:Health	ENS	O
_:691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:691:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:691:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:691:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:691:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:691:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:691:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:691:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:691:59	Inverse-T 1:Disk emulation running	SPS	O
_:691:55	Inverse-T 1:Pickup	ACD	O
_:691:56	Inverse-T 1:Operate delay expired	ACT	O
_:691:57	Inverse-T 1:Operate	ACT	O
_:691:302	Inverse-T 1:Fault	WYE	O

6.16.6 Stage with User-Defined Characteristic Curve

6.16.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the Inverse time-overcurrent protection - advanced stage (see chapter 6.16.5.1 Description). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 × 1.1 × threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

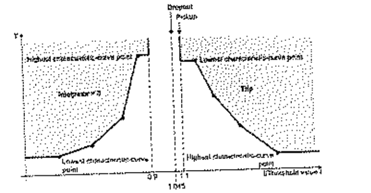


Figure 6-253 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

The currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic curve point. Currents that are larger than the current value of the largest characteristic curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic curve point.

6.16.6.2 Application and Setting Notes

This stage is structured the same way as the Inverse time overcurrent protection - advanced stage. The only difference is that you can define the characteristic curve as desired. This chapter provides only application and setting notes for setting characteristic curves.

Parameter: Current/time value pairs (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the Time dial parameter.

> **NOTE**
> The value pairs must be entered in continuous order.

Parameter: Time dial

- Default setting (_:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.

The set value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1.

Parameter: Reset

- Default setting (_:110) Reset = disk emulation

You use the Reset parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation but an instantaneous dropout is desired.

Parameter: Current/time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the Time dial parameter.

> **NOTE**
> The value pairs must be entered in continuous order.

Parameter: 1-pole operate allowed

- Default setting (_:11) 1-pole operate allowed = no

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (protection) in the tripping logic of the function group (Circuit breaker) is always 3-pole because the device does not support phase-selective tripping.

6.16.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:11	User curve #:1-pole operate allowed		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:120	User curve #:[illegible]		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:111	User curve #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.rdy		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.16.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn.set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.16.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.16.7.1 Description

With the Blk. w. inrush curr. detect. parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the tripping delay and the trip signal are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates. The following figure only shows the part of the stage (exemplified by definite time-overcurrent protection stage 1) that illustrates the influence of the blocking. Only if the central function inrush-current detection (see chapter 11.57 Inrush-Current Detection) is in effect can the blocking be set.

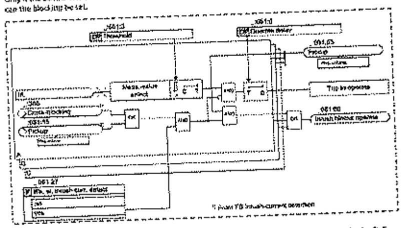


Figure 6-253 Part Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite Time-Overcurrent Protection Stage

6.16.7.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:661:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.

Parameter Value	Description
yes	When the transformer inrush current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.16.8 Influence of Other Functions via Dynamic Settings

6.16.8.1 Description

The parameters Threshold and Operate delay used for tripping are so-called dynamic settings. Depending on other functions, the settings of these parameters can be changed dynamically (see Figure 6-254). Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.

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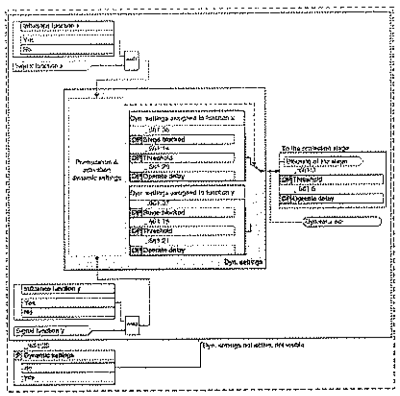

Figure 6-254 Principle of the Dynamic Settings Exemplified by 1st Definite Time-Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

Functionalities	Priority
Cold-load pickup detection	Priority 1
Binary input signal	Priority 2

These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings of the Threshold and Operate delay parameters are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter Influence of function ... and its own dynamic settings (Operate delay and Threshold). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for example, signal function x) becomes active and is to take effect, these settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

When several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 1 precedes that of priority 2. The settings assigned to signal 1 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*

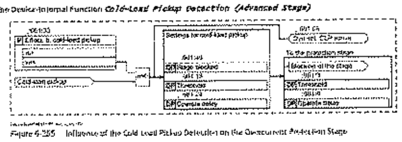

Figure 6-255 Influence of the Cold Load Pickup Detection on the Overcurrent Protection Stage

In the case of cold-load pickup, you have the option to change the settings for the Threshold and Operate delay parameters of the protection level. You can also block the level. To do so, you must activate the influence of the cold load pickup. You also have to set the Threshold and Operate delay or assign settings to Stage blocked, which take effect when the signal is active.

The way signals are generated Cold-load pickup is described in chapter 5.x.x.1 Overview of Functions.

Link to an External *Function via a Binary Input Signal (Advanced Stage)*

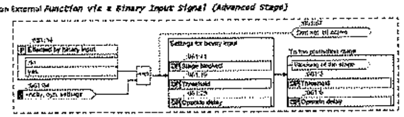

Figure 6-256 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal >Activ. dyn. settings to change the settings for the Threshold and the Operate delay parameters of the protection stage. You can also block the level. To do so, you must activate the influence of the binary input. You also have to set the Threshold and Operate delay or assign settings to Stage blocked, which take effect when the signal is active.

6.16.8.2 Application and Setting Notes (Advanced Stage)

Parameter: Dynamic settings

- Default setting (_:661:26) Dynamic settings = no

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.

Parameter Value	Description
yes	If a device-internal function (cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as changing the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to yes. This makes the configuration parameters Influence of function ... as well as the dynamic settings Threshold, Operate delay and Stage blocked of the stage visible and enables the settings to be set for the specific influence.

Influence of External Devices

The influence of an external device can also be configured.

To realize the application, the configuration setting Effected by binary input must be changed to yes (= influenced). This activates the >Activ. dyn. settings input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings.

6.17 Overcurrent Protection, Ground

6.17.1 Overview of Functions

The Overcurrent protection, ground function (ANSI 50N/51N):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.17.2 Structure of the Function

The Overcurrent protection, ground function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- Overcurrent protection, ground – advanced (50N/51N OC-gnd-A)
- Overcurrent protection, ground – basic (50N/51N OC-gnd-B)

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 Definite time-overcurrent protection stages and with 1 Inverse time-overcurrent protection stage.

In the function type Overcurrent protection, ground – advanced the following stages can be operated simultaneously:

- Maximum of 3 stages Definite time-overcurrent protection – advanced
- 1 stage Inverse time-overcurrent protection – advanced
- 1 stage User-defined characteristic curve overcurrent protection

In the function type Overcurrent protection, ground – basic the following stages can be operated simultaneously:

- Maximum of 3 stages Definite time-overcurrent protection – basic
- 1 stage Inverse time-overcurrent protection – basic

The non-preconfigured stages are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The measured-value selection (only advanced stage) is general functionality and has a uniform effect on the stages (see Figure 6-257 and chapter 6.17.3.1 Description). This ensures that all stages of the function receive the same measured current value.

The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- Pickup
- Operate

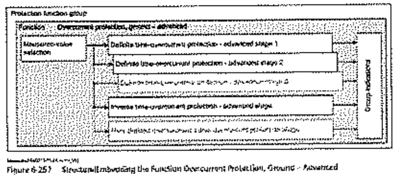

Figure 6-257 Structure/Embedding the Function Overcurrent Protection, Ground – Advanced

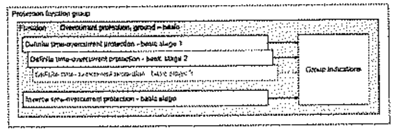

Figure 6-258 Structure/Embedding the Function Overcurrent Protection, Ground – Basic

If the following listed, device internal functions are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Cold-load pickup detection
- Binary input signal

If the device is equipped with an Inrush-current detection function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

6.17.3 General Functionality

6.17.3.1 Description

Measured-Value Selection

The function provides the option to select between the values IN measured or 3I0 calculated.

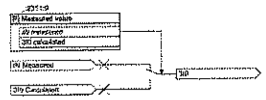

Figure 6-259 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types 3-phase + IN and 3-phase + IN-separate. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

Table 6-9 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		3 * Protection, 1 * sens.	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	0.15 A to 175.00 A	0.030 A to 35.000 A	0.15 A to 175.00 A
		3 * Protection, 1 * sens.	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.17.3.2 Application and Setting Notes

Parameter: Measured value

- Recommended setting value Measured value = IN Measured

This parameter is not available in the basic function.

Parameter Value	Description

ВЯРНО С ОРИГИНАЛА

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IN measured	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
3I0 calculated	The function operates with the calculated zero-sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

6.17.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured

6.17.4 Stage with Definite-Time Characteristic Curve

6.17.4.1 Description

Logic of the Basic Stage

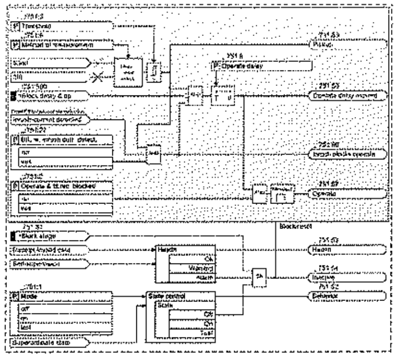

Figure 6-260 Logic Diagram of the Definite-Time Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage

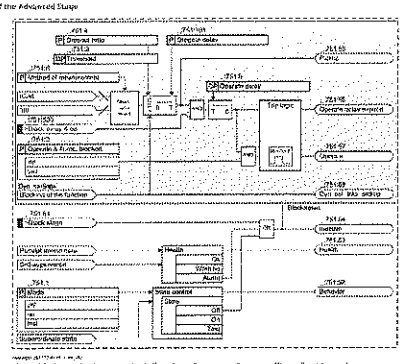

Figure 6-261 Logic Diagram of the Definite-Time Overcurrent Protection (Ground) – Advanced

Method of Measurement (Basic and Advanced Stage)

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage from an external or internal source
- Via the functionality of the dynamic settings (see chapter Influence of other functions via dynamic settings and section 6.1.7.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.17.3.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.1.7.1 Description.

6.17.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:751:8) Method of measurement = fundamental comp.

The Method of measurement parameter allows you to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the Threshold value of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Threshold, Operate delay

- Default setting (_:751:3) Threshold = 1.20 A (for the first stage)
- Default setting (_:751:6) Operate delay = 0.300 s (for the first stage)

Set the Threshold and Operate delay parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite time-overcurrent protection stage and 2nd stage = high-current stage):

1st stage (overcurrent stage):

The setting depends on the minimal occurring ground-fault current. This must be determined.

For very small ground-fault currents, Siemens recommends using the Ground-fault protection against high-resistance ground faults in grounded systems function.

The Operate delay to be set is derived from the time-grading schedule that has been prepared for the system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable

(one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the Threshold parameter to ensure that the stage does not pick up in case of a short-circuit at the end of the line.

Set the Operate delay parameter to 0 or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110 kV overhead line, 150 mm² cross-section

s (length)	= 60 km
Z_1/s	= 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: $Z_0/Z_1 = 4$

Short-circuit power at the beginning of the line:

S_k''	= 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: $Z_{0S}/Z_{1S} = 2$

Current transformer	= 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_S:

$$Z_L = 0.46\ \Omega/\text{km} \cdot 60\ \text{km} = 27.6\ \Omega$$

$$Z_S = \frac{110\ \text{kV}^2}{2500\ \text{MVA}} = 4.84\ \Omega$$

The 1-pole short-circuit current at the end of the line is $I_{sc\ end}$:

$$I_{sc\ end} = \frac{1.1 \cdot V_N \cdot 3}{\sqrt{3} \cdot \left|Z_S \cdot \left(2 + \frac{Z_{0S}}{Z_{1S}}\right) + Z_L \cdot \left(2 + \frac{Z_{0L}}{Z_{1L}}\right)\right|} = \frac{1.1 \cdot 110\ \text{kV} \cdot 3}{\sqrt{3} \cdot |4.84\ \Omega \cdot (2 + 2) + 27.6\ \Omega \cdot (2 + 4)|} = 1133\ \text{A}$$

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

Threshold value 2nd stage (primary) = 1.1 · 1133 A = 1246.3 A

Threshold value 2nd stage (secondary) $= 1.1 \cdot \frac{1133\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 10.39\ \text{A}$

In case of short-circuit currents exceeding 1246 A (primary) or 10.39 A (secondary) there is a short-circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance, line impedance and zero-sequence impedance have very different angles, you have to use complex numbers to calculate the threshold.

Parameter: Dropout delay

- Recommended setting value (_:751:101) Dropout delay = 0

This parameter is not visible in the basic stage.

Siemens recommends to use the default setting 0 since the dropout of a protection stage must be done as fast as possible.

You can use the Dropout delay parameter ≠ 0 to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: Dropout ratio

- Recommended setting value (_:751:4) Dropout ratio = 0.95

This parameter is not visible in the basic stage.

The recommended set value of 0.95 is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter Dropout ratio can be reduced, for example, to 0.98. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter Dropout ratio. This avoids chattering of the tripping stage.

6.17.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Emergency mode		• no • caused by main prot. • caused by binary input	no
General				
_:751:1	Definite-T 1:Mode		• off • on • test	off
_:751:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:751:26	Definite-T 1:Dynamic settings		• no • yes	no
_:751:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:751:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:751:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.010 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.05 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:751:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:751:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: AR off/n.rdy				
_:751:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:751:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:751:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:751:36	Definite-T 1:Stage blocked		• no • yes	no
_:751:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:751:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:751:37	Definite-T 1:Stage blocked		• no • yes	no
_:751:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:751:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:751:38	Definite-T 1:Stage blocked		• no • yes	no
_:751:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:751:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:751:39	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:751:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:751:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:751:40	Definite-T 1:Stage blocked		• no • yes	no
_:751:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: Bin.input				
_:751:34	Definite-T 1:Effected by binary input		• no • yes	no
_:751:41	Definite-T 1:Stage blocked		• no • yes	no
_:751:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
General				
_:752:1	Definite-T 2:Mode		• off • on • test	off
_:752:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:752:26	Definite-T 2:Dynamic settings		• no • yes	no
_:752:27	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:752:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.

Addr.	Parameter	C	Setting Options	Default Setting
_:752:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:752:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:752:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:752:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR off/n.rdy				
_:752:28	Definite-T 2:Effect. by AR off/n.ready		• no • yes	no
_:752:35	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:752:29	Definite-T 2:Effected by AR cycle 1		• no • yes	no
_:752:36	Definite-T 2:Stage blocked		• no • yes	no
_:752:14	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:752:20	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: AR cycle 2				
_:752:30	Definite-T 2:Effected by AR cycle 2		• no • yes	no
_:752:37	Definite-T 2:Stage blocked		• no • yes	no
_:752:15	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:752:21	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: AR cycle 3				
_:752:31	Definite-T 2:Effected by AR cycle 3		• no • yes	no
_:752:38	Definite-T 2:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:752:16	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:752:22	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR cycle>3				
_:752:32	Definite-T 2:Effected by AR cycle gr. 3		• no • yes	no
_:752:39	Definite-T 2:Stage blocked		• no • yes	no
_:752:17	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:752:23	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: Cold load PU				
_:752:33	Definite-T 2:Effect. b. cold-load pickup		• no • yes	no
_:752:40	Definite-T 2:Stage blocked		• no • yes	no
_:752:18	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:752:24	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: Bin.input				
_:752:34	Definite-T 2:Effected by binary input		• no • yes	no
_:752:41	Definite-T 2:Stage blocked		• no • yes	no
_:752:19	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:752:25	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s

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6.17.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emg. mode	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:751:81	Definite-T 1:>Block stage	SPS	I
_:751:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:751:500	Definite-T 1:>Block delay & op.	SPS	I
_:751:54	Definite-T 1:Inactive	SPS	O
_:751:52	Definite-T 1:Behavior	ENS	O
_:751:53	Definite-T 1:Health	ENS	O
_:751:60	Definite-T 1:Inrush blocks operate	ACT	O
_:751:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:751:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:751:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:751:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:751:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:751:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:751:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:751:55	Definite-T 1:Pickup	ACD	O
_:751:56	Definite-T 1:Operate delay expired	ACT	O
_:751:57	Definite-T 1:Operate	ACT	O

6.17.5 Stage with Inverse-Time Characteristic Curve

6.17.5.1 Description

Logic of the Basic Stage

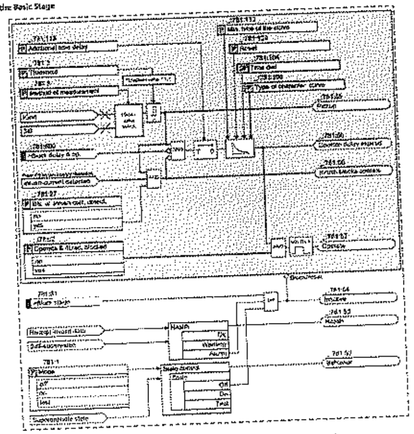

Figure 6-2x7 Logic Diagram of the Inverse-Time Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage

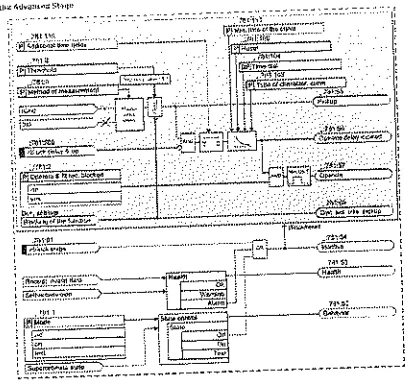

Figure 6-263 Logic Diagram of the Inverse Time-Overcurrent Protection (Ground) – Advanced

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter Min. time of the curve, you define the minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.

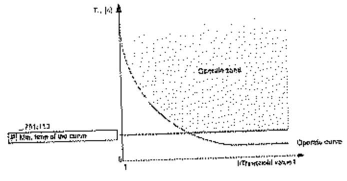

Figure 6-264 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time delay.

Method of Measurement (Basic and Advanced Stage)

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage from an external or internal source
- Via the functionality of the dynamic settings (see subtitle Influence of other functions via dynamic settings and chapter 6.17.8.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.17.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.17.8.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.17.8.1 Description.

6.17.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:781:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 I_{rated}.

Parameter: Type of character. curve

- Default setting (_:781:108) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application. For more information about the parameter Type of character. curve, refer to Chapter 11.14.2 Stage with Inverse-Time Characteristic Curve.

Parameter: Min. time of the curve

- Default setting (_:781:113) Min. time of the curve = 0.00 s

This parameter is only available in the advanced stage.

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve. This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Recommended setting value (_:781:115) Additional time delay = 0.00 s

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: Threshold

- Default setting (_:781:3) Threshold = 1.20 A

The setting depends on the minimal occurring ground-fault current. This must be determined.

Parameter: Time dial

- Default setting (_:781:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.

The set value for the Time dial parameter is derived from the time grading chart that has been prepared for the electrical power system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1.

Parameter: Reset

- Default setting (_:781:109) Reset = disk emulation

You use the Reset parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.17.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Frequency mode		• no • caused by main prot. • caused by binary input	no
General				
_:781:1	Inverse-T 1:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:781:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:781:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:781:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:781:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:781:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:108	Inverse-T 1:Type of character. curve			
_:781:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:781:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:781:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:781:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.ready				
_:781:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:781:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:781:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:781:36	Inverse-T 1:Stage blocked		• no • yes	no
_:781:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:781:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:781:37	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:781:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:781:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:781:38	Inverse-T 1:Stage blocked		• no • yes	no
_:781:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle>3				
_:781:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:781:39	Inverse-T 1:Stage blocked		• no • yes	no
_:781:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:781:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:781:40	Inverse-T 1:Stage blocked		• no • yes	no
_:781:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:781:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:781:41	Inverse-T 1:Stage blocked		• no • yes	no

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Addr.	Parameter	C	Setting Options	Default Setting
_:781:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.17.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emerg. mode	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:781:81	Inverse-T 1:>Block stage	SPS	I
_:781:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:781:500	Inverse-T 1:>Block delay & op.	SPS	I
_:781:54	Inverse-T 1:Inactive	SPS	O
_:781:52	Inverse-T 1:Behavior	ENS	O
_:781:53	Inverse-T 1:Health	ENS	O
_:781:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:781:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:781:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:781:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:781:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:781:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:781:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:781:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:781:59	Inverse-T 1:Disk emulation running	SPS	O
_:781:55	Inverse-T 1:Pickup	ACD	O
_:781:56	Inverse-T 1:Operate delay expired	ACT	O
_:781:57	Inverse-T 1:Operate	ACT	O

6.17.6 Stage with User-Defined Characteristic Curve

6.17.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the Inverse-time overcurrent protection – advanced stage (see chapter 6.17.5.1 Description). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The following figure shows the pickup and dropout behavior when a user-defined characteristic curve is used.

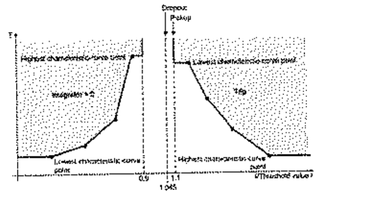

Figure 6-265 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.17.6.2 Application and Setting Notes

This stage is structured the same way as the Inverse-time overcurrent protection – advanced stage. The only difference is that the user can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves. For guidance on the other parameters of the stage, see chapter 6.17.5.2 Application and Setting Notes.

Parameter: Current/Time value pairs (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the Time dial parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

- Default setting (_:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.

The set value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter Time dial at 1 (default setting).

Parameter: Reset

- Default setting (_:110) Reset = disk emulation

You use the Reset parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/Time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the Time dial parameter.

NOTE

The value pairs must be entered in continuous order.

6.17.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.17.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.17.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.17.7.1 Description

With the Blk. w. inrush curr. detect. parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the tripping delay and the trip signal are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates. The following figure only shows the part of the stage (exemplified by definite time overcurrent protection stage 1) that illustrates the influence of the inrush-current detection. Only if the central function Inrush-current detection (see section 11.[illegible] Inrush-Current Detection) is in effect can the blocking be set.

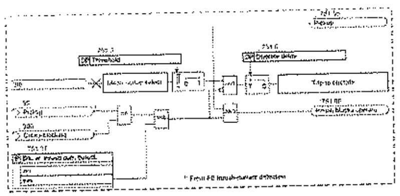

Figure 6-266 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite-Time Overcurrent Protection Stage

6.17.7.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:751:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: In cases where the device is not used on transformers. In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.17.8 Influence of Other Functions via Dynamic Settings

6.17.8.1 Description

The Threshold and Operate delay settings used for tripping are so-called dynamic settings. Depending on other functions, the settings of these parameters can be changed dynamically. Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.

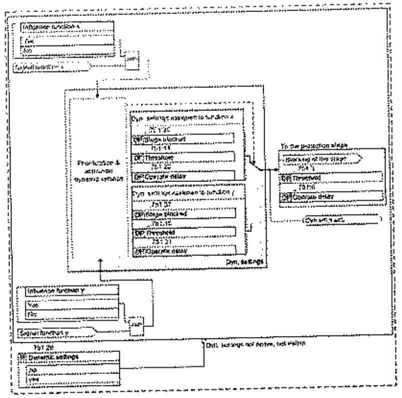

Figure 6-267 Principle of the Dynamic Settings in the Example of 1st Definite Time-Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

Functionalities	Priority
Cold-load pickup detection	Priority 1
Binary input signal	Priority 2

These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings for the Threshold and the Operate delay are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter Influence of function ... and its own dynamic settings (Operate delay and Threshold). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for example, signal function x) becomes active and is to take effect, these parameter settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

When several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 1 precedes that of priority 2. The settings assigned to signal 1 are thus active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function **Cold-Load Pickup Detection (Advanced Stage)**

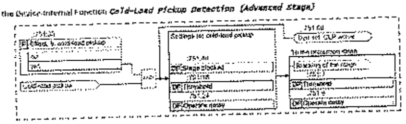

Figure 6-268 Influence of the Cold-Load Pickup Detection on the Overcurrent Protection Stage

You have the option of changing the settings for the Threshold and the Operate delay of the protection stage for a cold-load pickup. You can also block the stage. To do so, you must activate the influence of the cold-load pickup. You also have to set the Threshold and Operate delay or assign settings to Stage blocked, which take effect when the signal is active.

The way signals are generated Cold-load pickup is described in chapter Cold-Load Pickup Detection (Optional).

Link to an External **Function via a Binary Input Signal (Advanced Stage)**

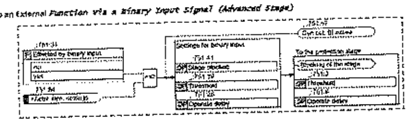

Figure 6-269 Influence of the Binary Input on the Overcurrent Protection Stage

You can use the binary input signal >Activ. dyn. settings to change the settings for the Threshold and the Operate delay of the protection stage. You can also block the stage. To do so, you must activate the influence of the binary input. You also have to set the Threshold and Operate delay or assign settings to Stage blocked, which take effect when the signal is active.

6.17.8.2 Application and Setting Notes (Advanced Stage)

Binary Input Signal>Dynamic settings

- Default setting (_:751:26) Dynamic settings = no

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.

Parameter Value	Description
yes	If a device-internal function (cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as changing the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to yes. This makes the configuration parameters Influence of function... as well as the dynamic settings Threshold, Operate delay and Stage blocked of the stage visible and enables the settings to be set for the specific influence.

Influence of External Devices

The influence of an external device can also be configured.

To realize the application, the configuration setting Effected by binary input must be changed to yes (= influenced). This activates the >Activ. dyn. settings input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings.

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6.18 Overcurrent Protection, 1-Phase

6.18.1 Function Overview

The Overcurrent protection, 1-phase function (ANSI 50N/51N):

- Detects and monitors the current measured in a transformer neutral point grounding
- Can operate as sensitive tank leakage protection
- Detects and monitors the circulating current between the neutral points of 2 capacitor banks
- Switches off high current faults instantaneously

6.18.2 Structure of the Function

The Overcurrent protection, 1-phase function is used in protection function groups with 1-phase current measurement. 2 function types are offered:

- Overcurrent protection, 1-phase – advanced (50N/51N OC 1ph-A)
- Overcurrent protection, 1-phase – basic (50N/51N OC 1ph-B)

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 Definite time-overcurrent protection stages and with 1 Inverse time-overcurrent protection stage.

In the function type Overcurrent protection, 1-phase – advanced the following stages can be operated simultaneously:

- Maximum of 3 stages Definite time-overcurrent protection (DMT)
- 1 stage Inverse time-overcurrent protection (IDMT)
- 1 stage User-defined characteristic curve overcurrent protection
- 1 Fast stage

In the function type Time-Overcurrent protection, 1-phase – Basic, the following stages can operate simultaneously:

- Maximum of 3 stages Definite time-overcurrent protection
- 1 stage Inverse time-overcurrent protection

The non-preconfigured stages in Figure 6-270 and Figure 6-271 are shown in gray. Apart from the operate-delay characteristic curve, the Definite time-overcurrent protection stage, the Inverse time-overcurrent protection stage, and the User-defined characteristic curve time-overcurrent protection stage are structured identically.

The Fast stage uses a fast tripping algorithm. It is therefore suited in particular for sensitive ground-fault detection according to the high-impedance principle.

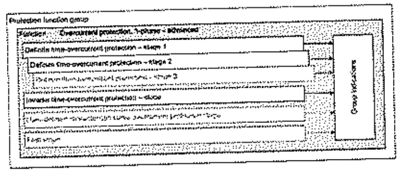

Figure 6-270 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Advanced

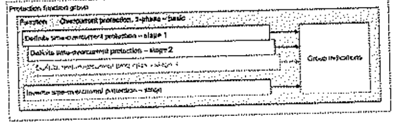

Figure 6-271 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Basic

If the device is equipped with the inrush-current detection function, you can stabilize the stages against tripping of the operate indications due to transformer inrush-currents.

6.18.3 Stage with Definite-Time Characteristic Curve

6.18.3.1 Description

Logic of a Stage

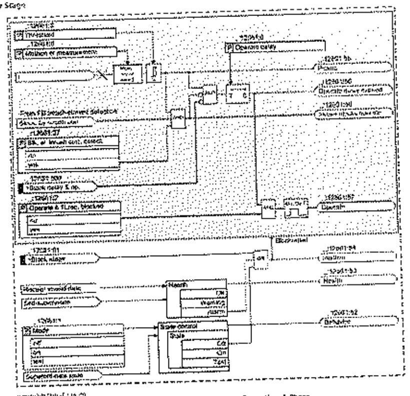

Figure 6-272 Logic Diagram of the Definite-Time Overcurrent Protection, 1 Phase

Method of measurement

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal >Block stage.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the Blk. w. inrush curr. detect. parameter, you can block the operate indication of the stage for a threshold-value violation due to the inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. When complete, the stage generates an operate indication. The blocking can only be set if the central function Inrush-current detection is effective.

Blocking of tripping with the inrush-current detection function is possible only if the following conditions have been met:

- The central inrush-current detection function has to be available in another protection function group with 3-phase current measurement.
- You have to connect the protection function group with 1-phase current measurement to the protection function group with 3-phase current measurement. You connect protection function groups in the DIGSI 5 Project tree → Name of the device → Function group connections.

Related Topics

6.14.7.1 Description

6.18.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:12661:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the Threshold value of the stage to less than $0.1\ I_{rated}$.

Parameter: Threshold, Operate delay

- Default setting (_:12661:3) Threshold = 1.200 A (for the first stage)
- Default setting (_:12661:6) Operate delay = 0.300 s (for the first stage)

Set the Threshold and Operate delay parameters for the specific application.

6.18.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:12661:1	Definite-T 1:Mode		• off • on • test	off
_:12661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Definite-T 2				
_:12662:1	Definite-T 2:Mode		• off • on • test	off
_:12662:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:12662:27	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:12662:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12662:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12662:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.30 s

6.18.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:12661:81	Definite-T 1:>Block stage	SPS	I
_:12661:500	Definite-T 1:>Block delay & op.	SPS	I
_:12661:54	Definite-T 1:Inactive	SPS	O
_:12661:52	Definite-T 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:12661:53	Definite-T 1:Health	ENS	O
_:12661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:12661:55	Definite-T 1:Pickup	ACD	O
_:12661:56	Definite-T 1:Operate delay expired	ACT	O
_:12661:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:12662:81	Definite-T 2:>Block stage	SPS	I
_:12662:500	Definite-T 2:>Block delay & op.	SPS	I
_:12662:54	Definite-T 2:Inactive	SPS	O
_:12662:52	Definite-T 2:Behavior	ENS	O
_:12662:53	Definite-T 2:Health	ENS	O
_:12662:60	Definite-T 2:Inrush blocks operate	ACT	O
_:12662:55	Definite-T 2:Pickup	ACD	O
_:12662:56	Definite-T 2:Operate delay expired	ACT	O
_:12662:57	Definite-T 2:Operate	ACT	O

6.18.4 Stage with Inverse-Time Characteristic Curve

6.18.4.1 Description

Logic of the Stage

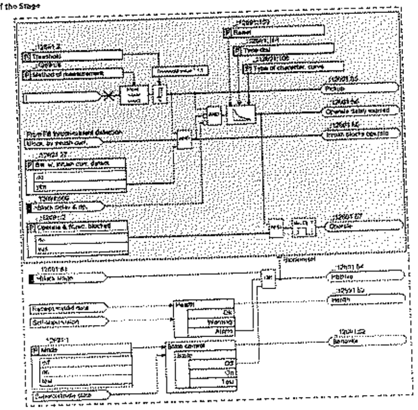

Figure 6-273 Logic Diagram of the Inverse-Time Overcurrent Protection (1-Phase)

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates. When the measured value falls short of the pickup value by a factor of 1.045 (0.95 × 1.1 × threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The

dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Method of Measurement

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal >Block stage.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the Blk. w. inrush curr. detect. parameter, you can block the operate indication of the stage for a threshold-value violation due to the inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. When complete, the stage generates an operate indication.

Blocking of tripping with the inrush-current detection function is possible only if the following conditions have been met:

- The central inrush-current detection function has to be available in another protection function group with 3-phase current measurement.
- You have to connect the protection function group with 1-phase current measurement to the protection function group with 3-phase current measurement. You connect protection function groups in the DIGSI 5 Project tree → Name of the device → Function group connections.

6.18.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:12691:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the Threshold value of the stage to less than $0.1\ I_{rated}$.

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Parameter: Type of character. curve

- Default setting (_:12691:108) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application.

Parameter: Threshold

- Default setting (_:12691:3) Threshold = 1.20 A

Set the Threshold and Type of character. curve parameters for the specific application.
Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the Threshold.

Parameter: Time dial

- Default setting (_:12691:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.
Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter Time dial at 1 (default setting).

Parameter: Reset

- Default setting (_:12691:109) Reset = disk emulation

You use the Reset parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.18.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T 1				
_:12691:1	Inverse-T 1:Mode		• off • on • test	off
_:12691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12691:108	Inverse-T 1:Type of charact. curve			

Addr.	Parameter	C	Setting Options	Default Setting
_:12691:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:12691:101	Inverse-T 1:Time dial		0.05 to 15.00	1.00

6.18.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:12691:81	Inverse-T 1:>Block stage	SPS	I
_:12691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:12691:54	Inverse-T 1:Inactive	SPS	O
_:12691:52	Inverse-T 1:Behavior	ENS	O
_:12691:53	Inverse-T 1:Health	ENS	O
_:12691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:12691:59	Inverse-T 1:Disk emulation running	SPS	O
_:12691:55	Inverse-T 1:Pickup	ACD	O
_:12691:56	Inverse-T 1:Operate delay expired	ACT	O
_:12691:57	Inverse-T 1:Operate	ACT	O

6.18.5 Stage with User-Defined Characteristic Curve

6.18.5.1 Description

The User-defined characteristic curve time-overcurrent protection stage is only available in the advanced function type.
This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

With the user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.
An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.
When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

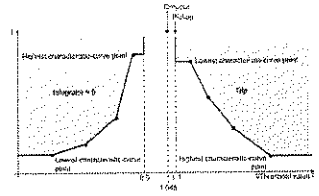

Figure 6-274 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.18.5.2 Application and Setting Notes

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: Current/time value pairs (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.
Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.
Set the time value in seconds. The characteristic curve is displaced using the Time dial parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

- Default setting (_:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.
Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1.

Parameter: Reset

- Default setting Reset = disk emulation

You use the Reset parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.
Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.
Set the time value in seconds. The characteristic curve is displaced using the Time dial parameter.

NOTE

The value pairs must be entered in continuous order.

6.18.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00

6.18.5.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.18.6 Fast Stage

6.18.6.1 Description

Logic of a Stage

The fast stage is only available in function type Advanced.

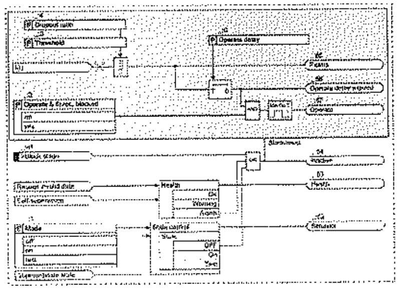

Figure 6-275 Logic Diagram of the Fast Stage, 1-Phase

Method of Measurement, Pickup and Dropout Behavior of the Fast Stage

This stage evaluates the unfiltered measurands. Thus, very short response times are possible. When the absolute values of 2 consecutive sampled values of the last half period exceed the Threshold, the stage picks up. When all sampled values of the previous period are less than the dropout threshold, the stage drops out.

Blocking of the Stage

The pickup of the stage can reset completely via the binary input signal >Block stage.

6.18.6.2 Application and Setting Notes

Parameter: Threshold, Operate delay

- Default setting (_:3) Threshold = 10.00 A
- Default setting (_:6) Operate delay = 0.00 s

Set the Threshold and Operate delay parameters for the specific application.
Ensure that the sampled values are compared directly without an additional factor with the set threshold value.

Parameter: Dropout ratio

- Recommended setting value (_:4) Dropout ratio = 0.90

The recommended setting value of 0.90 is sufficient for many applications. To obtain high-precision measurements, the Dropout ratio can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the Dropout ratio setting. This avoids chattering of the tripping stage.

6.18.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Fast stage #				
_:1	Fast stage #:Mode		• off • on • test	off
_:2	Fast stage #:Operate & flt.rec. blocked		• no • yes	no
_:3	Fast stage #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:4	Fast stage #:Dropout ratio		0.90 to 0.99	0.90
_:6	Fast stage #:Operate delay		0.00 s to 60.00 s	0.00 s

6.18.6.4 Information List

No.	Information	Data Class (Type)	Type
Fast stage #			
_:81	Fast stage #:>Block stage	SPS	I
_:54	Fast stage #:Inactive	SPS	O
_:52	Fast stage #:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
.:52	Fast stage #:Health	ENS	O
.:55	Fast stage #:Pickup	ACD	O
.:56	Fast stage #:Operate delay expired	ACT	O
.:57	Fast stage #:Operate	ACT	O

6.18.7 Application Example: High-Impedance Restricted Ground-Fault Protection

6.18.7.1 Description

With the high-impedance method, all current transformers operate in parallel at the limits of the protection range on a common, relatively high-impedance resistor R, the voltage of which is measured.

The current transformers must be of the same type of construction and have at least one core of their own for the high-impedance restricted ground-fault protection. Furthermore, they must have the same transfer ratio and approximately the same knee-point voltage.

The high-impedance principle is especially suited for ground-fault detection in grounded networks at transformers, generators, motors, and shunt reactors.

The left part of Figure 6-276 shows an application example for a grounded transformer winding or a grounded motor/generator. The example at the right shows an ungrounded transformer winding or an ungrounded motor/generator. In this example, it is assumed that the network is grounded at a different point.

Figure 6-276 Restricted Ground-Fault Protection According to the High-Impedance Principle

Function of the High-Impedance Principle

The high-impedance principle is explained using the example of a grounded transformer winding.

In normal state, no residual currents flow, that is, in the transformer neutral point $I_Y = 0$ and in the phases $3I_0 = I_A + I_B + I_C = 0$.

With an external ground fault (on the left in Figure 6-277), the short-circuit current of which is fed via a grounded neutral point, the same current flows in the transformer neutral point and in the phases. The respective secondary currents (with the same transfer ratio of all current transformers) draw each other off. They are connected in series. At the resistor R, only a little voltage arises, which results from the internal resistances of the transformers and those of the transformer connection lines. Even if a current transformer is briefly saturated, it becomes a low impedance during the time of the saturation and forms a low-impedance shunt to the high-impedance resistor R. The high resistance of the resistor thus has a stabilizing effect (so-called resistor stabilization).

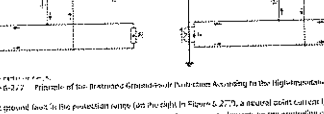

Figure 6-277 Principle of the Restricted Ground-Fault Protection According to the High-Impedance Principle

With a ground fault in the protection range (on the right in Figure 6-277), a neutral-point current I_Y flows in any case. The magnitude of the residual current in the phase currents depends on the grounding conditions in the rest of the network. A secondary current corresponding to the entire short-circuit current attempts to flow via the resistor R. But since this resistor is high impedance, a high voltage arises there which causes the saturation of the current transformers. The effective voltage at the resistor therefore corresponds approximately to the knee-point voltage of the current transformers.

The resistor R is thus dimensioned in such a way that even the smallest ground-fault current to be detected leads to a secondary voltage that corresponds to half of the knee-point voltage of the current transformers (see chapter 7.5.4).

Further information can be found at Sensitivity view for high-impedance ground-fault differential protection in chapter 6.18.7.2 Application and Setting Notes .

High-Impedance Restricted Ground-Fault Protection with a SIPROTEC 5 Device

Use the I4 measuring input of the SIPROTEC 5 device for the high-impedance restricted ground-fault protection. This input for this application is to be executed as a sensitive measuring input. Since this is a current input, the current is detected by this resistor instead of the voltage at the resistor R.

Figure 6-278 shows the connection diagram. The protection device is connected in series with the resistor R and thus measures its current.

The varistor V limits the voltage in case of an internal fault. The varistor cuts the high instantaneous voltage peaks in the case of transformer saturation. Simultaneously, a smoothing of the voltage arises without any relevant reduction of the average value.

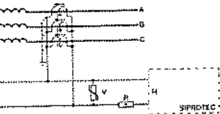

Figure 6-278 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

As a protection against overvoltages, it is important that you connect the device directly at the grounded side of the current transformer. The high voltage at the resistor is thus kept away from the device.

In a similar manner, the high-impedance restricted ground-fault protection for generators, motors, and shunt reactors is used. With auto transformers, you must connect the upper voltage side and low voltage side current transformers and neutral-point transformer in parallel.

The method can be realized for each protected object. As busbar protection, the device, for example, is connected via the resistor to the parallel connection of the transformers of all feeders.

6.18.7.2 Application and Setting Notes

A prerequisite for the application of the high-impedance restricted ground-fault protection is that neutral-point current detection is possible on the neutral side (see example in Figure 6-278). Furthermore, a sensitive input transformer must be available at device input I4. Set the pickup value for current at input I4 with the function **Overcurrent protection, 1-phase**.

Observe the interaction between current transformer characteristic curve, external resistor R, and the voltage at R for the overall function of the high-impedance restricted ground-fault protection. Notes on this follow.

Current Transformer Data for High-Impedance Restricted Ground-Fault Protection

All affected current transformers must have the same ratio and approximately the same knee-point voltage. This is normally the case when the current transformers are of the same type and have the same rated data. You can calculate the knee-point voltage from the rated data as follows:

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2}\right) \cdot n \cdot I_{rated}$$

V_{KP}	Knee-point voltage
Ri	Internal resistance of the current transformer
P_{rated}	Rated power of the current transformer
I_{rated}	Secondary rated current of the current transformer
n	Rated overcurrent factor

Rated current, rated power, and overcurrent factor are found on the name plate of the transformer.

EXAMPLE

Current transformer with the following data on the name plate: 800/5; 5P10; 30 VA

You can read the following transformer data with the data:

I_{rated} = 5 A (out of 800/5)

n = 10 (out of 5P10)

P_{rated} = 30 VA

The internal resistance is frequently to be found in the test report of the transformer. If it is not known, it can be approximately determined by a direct current measurement of the secondary winding.

EXAMPLE

Calculation of the knee-point voltage

Current transformer 800/5; 5P10; 30 VA with R_i = 0.3 Ω

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2}\right) \cdot n \cdot I_{rated} = \left(0.3\ \Omega + \frac{30\ VA}{(5\ A)^2}\right) \cdot 10 \cdot 5\ A = 75\ V$$

Current transformer 800/1; 5P10; 30 VA with R_i = 5 Ω

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2}\right) \cdot n \cdot I_{rated} = \left(5\ \Omega + \frac{30\ VA}{(1\ A)^2}\right) \cdot 10 \cdot 1\ A = 350\ V$$

Besides the current-transformer data, the resistance of the longest connection line between transformer and device must be known.

Stability Consideration for High-Impedance Restricted Ground-Fault Protection

The stability condition is based on the simplified assumption that one current transformer is completely saturated and the others transfer their partial currents proportionately in the case of an external fault. This is theoretically the worst case. A safety margin is automatically provided, since, in practice, even the saturated transformer still delivers some current.

Figure 6-279 shows an equivalent circuit of this simplification. CT1 and CT2 are assumed to be ideal transformers with their internal resistances R_i and R_{i2}. R_L are the core resistances of the connection lines between transformer and resistance R; they are used doubled (forward line and return line). R_{L2} is the resistance of the longest connection line.

CT1 transmits the current I1. CT2 is assumed to be saturated. This is indicated by the dotted short-circuit line. The transformer thus represents a low-impedance shunt by its saturation.

A further prerequisite is $R >> (2R_{L2} + R_{i2})$.

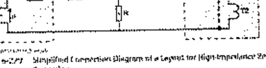

Figure 6-279 Simplified Connection Diagram of a Layout for High-Impedance Restricted Ground-Fault Protection

The voltage at R is, then,

$V_R = I_1 \cdot (2R_{L2} + R_{i2})$

A further assumption is that the pickup value of the SIPROTEC 5 device corresponds to half of the knee-point voltage of the current transformers. In the edge case,

$V_R = V_{KP}/2$

The stability limit I_{SL} results, which means the through current up to which the arrangement remains stable:

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{L2} + R_{i2}}$$

EXAMPLE

For the 5 A transformer as above with V_{KP} = 75 V and R_i = 0.3 Ω

Longest connection line = 22 m with 4 mm² cross-section; that corresponds to R_L = 0.1 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{L2} + R_{i2}} = \frac{37.5\ V}{2 \cdot 0.1\ \Omega + 0.3\ \Omega} = 75\ A$$

In the example, the stability limit is 15 x rated current or 12 kA primary.

For the 1 A transformer as above with V_{KP} = 350 V and R_i = 5 Ω

Longest connection line = 107 m with 2.5 mm² cross-section; that corresponds to R_L = 0.75 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{L2} + R_{i2}} = \frac{175\ V}{2 \cdot 0.75\ \Omega + 5\ \Omega} = 27\ A$$

In the example, the stability limit is 27 x rated current or 21.6 kA primary.

Sensitivity Consideration for High-Impedance Restricted Ground-Fault Protection

The voltage present at the set of current transformers is supplied to the protection device via a series resistor R as proportional current for evaluation. For dimensioning of the resistor, the following must be taken into account:

The high-impedance restricted ground-fault protection should pick up at approximately half of the knee-point voltage of the current transformers. From this, you can calculate the resistor R.

Since the device measures the current through the resistor, the resistor and measuring input of the device must be connected in series. Since the resistor still should be high-impedance (aforementioned condition $R >> 2R_{L2} + R_{i2}$), the inherent resistance of the measuring input can be neglected. The resistance results thus from the pickup current I_{pick} and half of the knee-point voltage:

$$R = \frac{V_{KP}/2}{I_{pick}}$$

EXAMPLE

For the 5 A transformer as above

Desired pickup value I_{pick} = 0.1 A (corresponds to 16 A primary)

$$R = \frac{V_{KP}/2}{I_{pick}} = \frac{75\ V/2}{0.1\ A} = 375\ \Omega$$

For the 1 A transformer as above

Desired pickup value I_{pick} = 0.05 A (corresponds to 40 A primary)

$$R = \frac{V_{KP}/2}{I_{pick}} = \frac{350\ V/2}{0.05\ A} = 3500\ \Omega$$

The series resistor R must be designed for a minimum continuous load $P_{continuous}$:

$$P_{continuous} = \frac{(V_{KP}/2)^2}{R} = \frac{37.5^2}{375} = 3.75\ W \quad \text{at the 5-A-transformer}$$

$$P_{continuous} = \frac{(V_{KP}/2)^2}{R} = \frac{175^2}{3500} = 8.75\ W \quad \text{at the 1-A-transformer}$$

Further, the series resistor R must be designed for a fault current lasting approximately 0.5 s. This time is usually sufficient for fault clarification through backup protection.

The thermal stress of the series resistor depends on the voltage $V_{rms,dist}$ that is present during an internal fault. It is calculated according to the following equations:

$$V_{rms,dist} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{75^3 \cdot 375 \cdot 250} = 570.7\ V \quad \text{at the 5-A-transformer}$$

$$V_{rms,dist} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{350^3 \cdot 3500 \cdot 50} = 2151.6\ V \quad \text{at the 1-A-transformer}$$

$I_{K,max,int}$ corresponds to the maximum fault current here in the case of an internal fault.

5-A current transformer 800/5 with 40 kA primary corresponds to $I_{K,max,int}$ = 250 A secondary.

1-A current transformer 800/1 with 40 kA primarily corresponds to $I_{K,max,int}$ = 50 A secondary.

This results in a temporary load for the series resistor over 0.5 s of:

$$P_{0.5s} = \frac{V_{rms,dist}^2}{R} = \frac{570.7^2}{375} = 868\ W \quad \text{at the 5-A-transformer}$$

$$P_{0.5s} = \frac{V_{rms,dist}^2}{R} = \frac{2151.6^2}{3500} = 1322.7\ W \quad \text{at the 1-A-transformer}$$

Observe that with the selection of a higher pickup value I_{pick} the resistor value must be lowered and therefore the dissipation rises sharply.

The varistor (see following figure) must be sized such that it remains high impedance up to the knee-point voltage, for example:

- Approx. 100 V with 5 A transformer
- Approx. 500 V with 1 A transformer

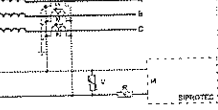

Figure 6-280 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

Even with unfavorable wiring, the maximum occurring voltage peaks do not exceed 2 kV for safety reasons.

Where for performance reasons, several varistors must be connected in parallel, give preference to types with flat characteristic curves, in order to avoid an unbalanced load. Siemens therefore recommends the following types by METROSIL:

600A/S1/S256 (k = 450, β = 0.25)

600A/S1/S1088 (k = 900, β = 0.25)

In the example, set the pickup value of the first Definite time overcurrent protection stage (setting Threshold) to 0.1 A for 5-A transformers or 0.05 A for 1-A transformers. No further protection stages are needed. Delete these or switch them off. Set the Operate delay setting to 0 s.

If several current transformers are connected in series, for example, with use as busbar protection with several feeders, the magnetization currents of the transformers switched in parallel can no longer be neglected. In

In this case, additional magnetization currents at half of the knee-point voltage (corresponds to the set Threshold). These magnetization currents reduce the current through the resistor R. Thus, the actual pickup value is correspondingly higher.

6.18.8 Application Example: Tank Leakage Protection

6.18.8.1 Description

Tank leakage protection records short-circuits to ground – including high-impedance ones – between a phase and the tank of a transformer. The tank is thus insulated, or at least grounded with high impedance. The tank must be connected with a line to ground. The current that flows through this line is fed to the protection device. If a short-circuit to ground occurs in a tank, a fault current (tank current) flows to substation ground via the ground connection.

The function Overcurrent protection, 1-phase detects the tank current. If the tank current exceeds the set Threshold, the function Overcurrent protection, 1-phase generates an operate indication. Depending on the set Operate delay, the transformer is tripped immediately or time-delayed on all sides.

For tank protection, a sensitive, 1-phase current measuring input is used.

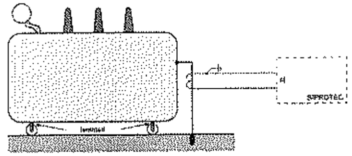

Figure 6-281 Tank-Control Principle

6.18.8.2 Application and Setting Notes

A prerequisite for the application of tank protection is the availability of a sensitive input transformer at device input I4.

If you connect Measuring point I-1ph with the function group Voltage-current 1-phase, the function Overcurrent protection, 1-phase works with the 1-phase current connected to input I4.

Use only the first definite time-overcurrent protection stage of function Overcurrent protection, 1-phase. The Threshold setting is used to set the pickup value. No further protection stages are needed. Delete these or switch them off. Set the Operate delay setting to 0 s.

6.19 Voltage-Dependent Overcurrent Protection, Phases

6.19.1 Overview of Functions

The Voltage-dependent overcurrent protection (ANSI 51V) function:

- Detects short circuits affecting electric equipment
- Can be used for special network conditions where the overcurrent pickup level should be decreased depending on the fault voltage
- Can be used for generators where the excitation voltage is derived from the machine terminals and the overcurrent pickup should be kept depending on the fault voltages

6.19.2 Structure of the Function

The Voltage-dependent overcurrent protection function is used in protection function groups with 3-phase current and voltage measurement.

The function Voltage-dependent overcurrent protection comes with the following factory-set stages:

- Inverse time-overcurrent protection, voltage-dependent stage
- Definite time-overcurrent protection, undervoltage seal-in stage

In this function, the following stages can operate simultaneously:

- A maximum of 2 inverse time-overcurrent protection, voltage-dependent stages
- A maximum of 2 inverse time-overcurrent protection, voltage-released stages
- A maximum of 2 definite time-overcurrent protection, undervoltage seal-in stages
- A maximum of 2 definite time-overcurrent protection, voltage released undervoltage seal-in stages

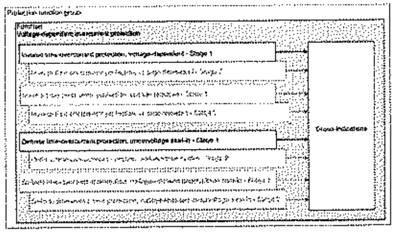

Figure 6-282 Structure/Embedding of the Function

6.19.3 Stage with Inverse Time-Overcurrent Protection, Voltage-Dependent

6.19.3.1 Description

Logic of the Stage

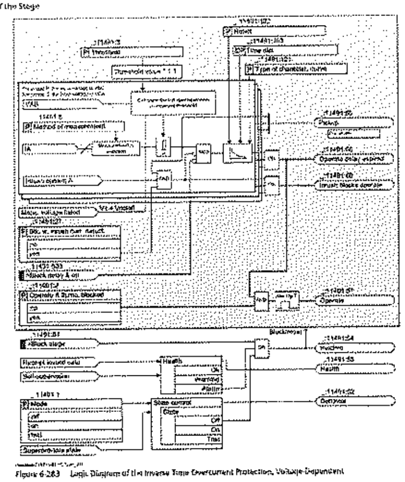

Figure 6-283 Logic Diagram of the Inverse Time Overcurrent Protection, Voltage-Dependent

Method of Measurement

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

- Measurement of the fundamental comp.:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Voltage-Dependent Pickup Threshold

The pickup threshold of the overcurrent stage depends on the voltage magnitude. A lower voltage decreases the current pickup value (see Figure 6-284). In the range between V/V_{rated} = 1.00 to 0.25 a linear, directly proportional dependence is realized.

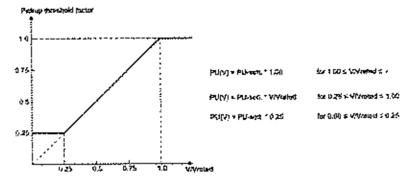

Figure 6-284 Voltage Influence of the Pickup Threshold

Where:

V	=	Measured phase-to-phase voltage
V_{rated}	=	Rated voltage (parameter Rated voltage in the function block General of the protection function group)
PU sets.	=	Pickup threshold setting (parameter address: _:11491:3)
PU(V)	=	Applied pickup threshold according to the voltage influence

The minimum current pickup threshold value is 0.03 * Irated. This value cannot be decreased any further even not by voltage-dependent pickup threshold factor.

Decreasing the pickup threshold is carried out phase-selectively. The assignment of voltages to current-carrying phases is shown in Table 6-10.

Table 6-10 Controlling Voltages in Relation to the Fault Current

Current	Controlling Voltage
I_A	V_{AB}
I_B	V_{BC}
I_C	V_{CA}

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve According to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by 1.045 times (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to the characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Influence On the Operate Curve

The current pickup threshold is decreased proportional to the voltage decrease. Consequently, for a constant current I the I/threshold-value ratio is increased and the operate time is reduced. Compared with the standard curves represented in the Technical Data, the operate curve shifts to the left side as the voltage decreases.

Measuring-Voltage Failure Detection

In case of a measuring-voltage failure detection the input voltage value is automatically set to V_{rated}, so that the pickup threshold factor will be 1.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.16.7.1 Description.

6.19.3.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:11491:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Method of measurement

- Recommended setting value (_:11491:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).

Parameter: Threshold

- Default setting (_:11491:3) Threshold = 1.500 A

The recommended setting value of 1.500 A is suitable for most applications.

Set the Threshold and Type of character. curve parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection.

Set the Threshold parameter for lines to approx. 10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the Threshold.

Parameter: Type of character. curve

- Default setting (_:11491:101) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application.

Parameter: Reset

- Default setting (_:11491:102) Reset = disk emulation

The Reset parameter allows you to define whether the stage decreases according to the dropout characteristic curve (behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout does not have to be performed after a disk emulation and an instantaneous dropout is desired instead.

Parameter: Time dial

- Default setting (_:11491:103) Time dial = 1

You can use the Time dial parameter to displace the characteristic curve in the time direction.

The setting value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter Time dial at 1 (default setting).

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6.19.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-dependent 1				
_:11491:1	V-dependent 1:Mode		• off • on • test	off
_:11491:2	V-dependent 1:Operate & flt.rec. blocked		• no • yes	no
_:11491:27	V-dependent 1:Blk. w. inrush curr. detect.		• no • yes	no
_:11491:8	V-dependent 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:11491:3	V-dependent 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:11491:101	V-dependent 1:Type of character. curve			
_:11491:102	V-dependent 1:Reset		• instantaneous • disk emulation	disk emulation
_:11491:103	V-dependent 1:Time dial		0.05 to 15.00	1.00

6.19.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
V-dependent 1			
_:11491:81	V-dependent 1:>Block stage	SPS	I
_:11491:500	V-dependent 1:>Block delay & op.	SPS	I
_:11491:54	V-dependent 1:Inactive	SPS	O
_:11491:52	V-dependent 1:Behavior	ENS	O
_:11491:53	V-dependent 1:Health	ENS	O
_:11491:60	V-dependent 1:Inrush blocks operate	ACT	O
_:11491:59	V-dependent 1:Disk emulation running	SPS	O
_:11491:55	V-dependent 1:Pickup	ACD	O
_:11491:56	V-dependent 1:Operate delay expired	ACT	O
_:11491:57	V-dependent 1:Operate	ACT	O

6.19.4 Stage with Inverse Time-Overcurrent Protection, Voltage-Released

6.19.4.1 Description

Logic of the Stage

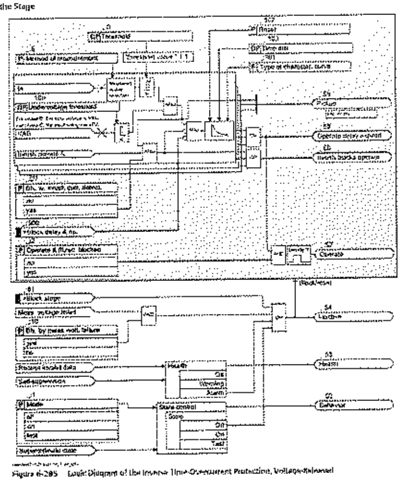

Figure 6-285 Logic Diagram of the Inverse Time-Overcurrent Protection, Voltage-Released

This stage is structured in the same way as the inverse time-overcurrent, voltage-dependent stage (see chapter 6.19.3.1 Description). The only differences are the conditions for the pickup and the influence on the operate curve.

Measuring Element Release

When the controlling voltage drops below the setting Undervoltage threshold, the respective measuring element is released.

The release of the measuring elements is carried out phase-selectively. The assignment of voltages to current carrying phases is shown in Figure 6-284.

Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In case of a blocking, the picked up stage is reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Volt.-transf. c. b., which links in the tripping of the voltage-transformer circuit breaker

The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.19.4.2 Application and Setting Notes

This stage is structured in the same way as the inverse time-overcurrent, voltage-dependent stage. The only differences are the conditions for the pickup and the influence on the operate curve. This chapter only provides the application and setting notes for the setting Blk. by meas.-volt. failure and Undervoltage threshold. For guidance on the other parameters of this stage, refer to chapter 6.19.3.2 Application and Setting Notes.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:10) Blk. by meas.-volt. failure = yes

You can use the Blk. by meas.-volt. failure parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal Measuring-voltage failure detection function is configured and switched on.
- The binary input signal >Open of the function block Voltage-transformer circuit breaker is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
no	The overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.
yes	The overcurrent-protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct operation of the stage cannot be guaranteed if a measuring-voltage failure occurs.

Parameter: Undervoltage threshold

- Default setting (_:104) Undervoltage threshold = 75.0 V

When the controlling voltage is below the set value, the inverse time-overcurrent stage is released.

The parameter is set to a value just below the lowest phase-to-phase voltage admissible during operation, for example, from 75 % to 80 % of V_{rated}.

6.19.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-release 1				
_:1	V-release 1:Mode		• off • on • test	off
_:7	V-release 1:Operate & flt.rec. blocked		• no • yes	no
_:10	V-release 1:Blk. by meas.-volt. failure		• no • yes	yes
_:27	V-release 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8	V-release 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	V-release 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:101	V-release 1:Type of character. curve		• ANSI long-time inv. • ANSI short-time inv. • ANSI extremely inv. • ANSI very inverse • ANSI normal inverse • ANSI moderately inv. • ANSI definite inverse • IEC normal inverse • IEC very inverse • IEC extremely inv. • IEC long-time inverse	IEC normal inverse
_:102	V-release 1:Reset		• instantaneous • disk emulation	disk emulation
_:103	V-release 1:Time dial		0.05 to 15.00	1.00
_:104	V-release 1:Undervoltage threshold		0.300 V to 175.000 V	75.000 V

6.19.4.4 Information List

No.	Information	Data Class (Type)	Type
V-release 1			
_:81	V-release 1:>Block stage	SPS	I
_:500	V-release 1:>Block delay & op.	SPS	I
_:54	V-release 1:Inactive	SPS	O
_:52	V-release 1:Behavior	ENS	O
_:53	V-release 1:Health	ENS	O
_:60	V-release 1:Inrush blocks operate	ACT	O
_:59	V-release 1:Disk emulation running	SPS	O
_:55	V-release 1:Pickup	ACD	O
_:56	V-release 1:Operate delay expired	ACT	O
_:57	V-release 1:Operate	ACT	O

6.19.5 Stage with Definite Time-Overcurrent Protection, Undervoltage Seal-In

6.19.5.1 Description

Logic of the Stage

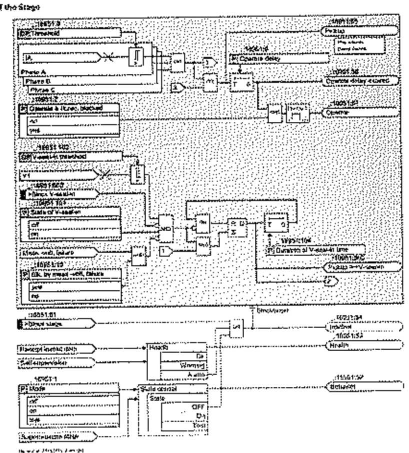

Figure 6-286 Logic Diagram of the Definite Time-Overcurrent Protection, Undervoltage Seal-In

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short circuit fault.

The pickup signal is maintained for a settable seal-in time Duration of V-seal-in time, if the positive-sequence voltage falls below a settable threshold V-seal-in threshold after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input >Block V-seal-in, the signal Pickup I>+V-seal-in drops out immediately.

You can switch off the undervoltage seal-in via the parameter State of V-seal-in.

Blocking of the Undervoltage Seal-In with Measuring-Voltage Failure

The Undervoltage seal-in can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal Pickup I>+V-seal-in drops out immediately. The following blocking options are available for the Undervoltage seal-in:

- From an internal source upon pickup of the Measuring-voltage failure detection function.
- From an external source via the binary input signal >Open of the function block VT miniature CB, which links in the tripping of the voltage-transformer circuit breaker.

The parameter Blk. by meas.-volt. failure can be used to control the measuring-voltage failure detection. The Undervoltage seal-in remains unaffected if the parameter Blk. by meas.-volt. failure is switched off.

6.19.5.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:16851:2) Operate & flt.rec. blocked = no

With the parameter Operate & flt.rec. blocked, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting (_:16851:3) Threshold = 1.350 A

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the Threshold parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

- Default setting (_:16851:6) Operate delay = 3.00 s

The parameter Operate delay must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

- Default setting (_:16851:10) Blk. by meas.-volt. failure = yes

With the parameter Blk. by meas.-volt. failure, you can activate (yes) or deactivate (no) the blocking by the Measuring-voltage failure detection function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting (_:16851:101) State of V-seal-in = off

With the parameter State of V-seal-in, the seal-in functionality can be activated (switched on). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

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Parameter: V-seal-in threshold

- Default setting (_:16951:102) V-seal-in threshold = 46.2 V

The V-seal-in threshold (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, CT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, CT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{rated, Gen}}{I_{rated, CT, prim}} \times I_{rated, CT, sec} = \frac{1.4 \times 483\ A}{500\ A} \times 1\ A = 1.35\ A$$

$$\text{Undervoltage seal-in} = \frac{0.8 \times V_{rated, Gen}}{V_{rated, VT, prim}} \times \frac{V_{rated, VT, sec}}{\sqrt{3}} = \frac{0.8 \times 6.3\ kV}{6.3\ kV} \times \frac{100\ V}{\sqrt{3}} = 46.200\ V$$

Parameter: Duration of V-seal-in time

- Default setting (_:16951:104) Duration of V-seal-in time = 4.00 s

The parameter Duration of V-seal-in time limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter Operate delay. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

6.19.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-seal-in 1				
_:16951:1	V-seal-in 1:Mode		• off • on • test	off
_:16951:2	V-seal-in 1:Operate & flt.rec. blocked		• no • yes	no
_:16951:3	V-seal-in 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:16951:6	V-seal-in 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:16951:10	V-seal-in 1:Blk. by meas.-volt. failure		• no • yes	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:16951:101	V-seal-in 1:State of V-seal-in		• off • on	off
_:16951:102	V-seal-in 1:V-seal-in threshold		0.300 V to 175.000 V	80.010 V
_:16951:104	V-seal-in 1:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s

6.19.5.4 Information List

No.	Information	Data Class (Type)	Type
V-seal-in 1			
_:16951:81	V-seal-in 1:>Block stage	SPS	I
_:16951:500	V-seal-in 1:>Block V-seal-in	SPS	I
_:16951:52	V-seal-in 1:Behavior	ENS	O
_:16951:53	V-seal-in 1:Health	ENS	O
_:16951:54	V-seal-in 1:Inactive	SPS	O
_:16951:55	V-seal-in 1:Pickup	ACD	O
_:16951:300	V-seal-in 1:Pickup I>+V-seal-in	SPS	O
_:16951:56	V-seal-in 1:Operate delay expired	ACT	O
_:16951:57	V-seal-in 1:Operate	ACT	O

6.19.6 Stage with Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-In

6.19.6.1 Description

Logic of the Stage

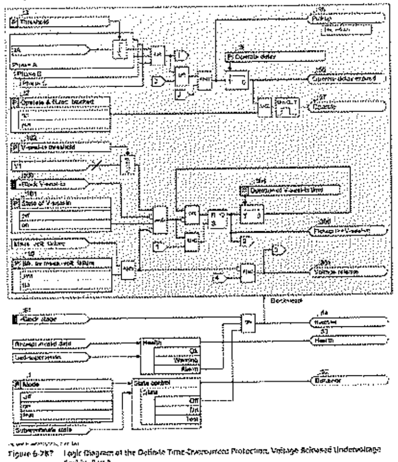

Figure 6-287 Logic Diagram of the Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-In, Part 1

Signal 4 in the following figure refers to Figure 6-287.

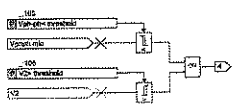

Figure 6-288 Logic Diagram of the Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-In, Part 2

Voltage Release

In addition to the current criterion with undervoltage seal-in, a voltage-released logic must be present to issue the indication Pickup. The voltage-released logic monitors the negative-sequence voltage and phase-to-phase voltages respectively for detecting unsymmetrical faults and symmetrical faults. With the voltage-released logic, the setting value of the parameter Threshold can be reduced in a certain range and the reliability and sensibility of this function can be improved correspondingly.

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltage is used as an additional criterion for detecting a short-circuit fault.

The pickup signal is maintained for a settable seal-in time Duration of V-seal-in time, if the positive-sequence voltage falls below a settable threshold V-seal-in threshold after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has expired, or if the undervoltage seal-in is blocked via a binary input >Block V-seal-in, the signal Pickup I>+V-seal-in drops out immediately.

You can switch off the undervoltage seal-in via the parameter State of V-seal-in.

Blocking of the Undervoltage Seal-In with Measuring-Voltage Failure

The undervoltage seal-in can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal Pickup I>+V-seal-in drops out immediately. The following blocking options are available for the undervoltage seal-in:

- From an internal source upon pickup of the Measuring-voltage failure detection function.
- From an external source via the binary input signal >Open of the function block VT miniature CB, which links in the tripping of the voltage-transformer circuit breaker.

The parameter Blk. by meas.-volt. failure can be used to control the measuring-voltage failure detection. The undervoltage seal-in remains unaffected if the parameter Blk. by meas.-volt. failure is switched off.

6.19.6.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

With the parameter Operate & flt.rec. blocked, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting (_:3) Threshold = 1.350 A

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the Threshold parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 3.00 s

The parameter Operate delay must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

- Default setting (_:10) Blk. by meas.-volt. failure = yes

With the parameter Blk. by meas.-volt. failure, you can activate (yes) or deactivate (no) the blocking by the Measuring-voltage failure detection function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting (_:101) State of V-seal-in = off

With the parameter State of V-seal-in, the seal-in functionality can be activated (switched on). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: V-seal-in threshold

- Default setting (_:102) V-seal-in threshold = 46.2 V

The V-seal-in threshold (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V-seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, CT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, CT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{rated, Gen}}{I_{rated, CT, prim}} \times I_{rated, CT, sec} = \frac{1.4 \times 483\ A}{500\ A} \times 1\ A = 1.35\ A$$

$$\text{Undervoltage seal-in} = \frac{0.8 \times V_{rated, Gen}}{V_{rated, VT, prim}} \times \frac{V_{rated, VT, sec}}{\sqrt{3}} = \frac{0.8 \times 6.3\ kV}{6.3\ kV} \times \frac{100\ V}{\sqrt{3}} = 46.200\ V$$

Parameter: Duration of V-seal-in time

- Default setting (_:104) Duration of V-seal-in time = 4.00 s

The parameter Duration of V-seal-in time limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter Operate delay. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

Parameter: Vph-ph< threshold

- Default setting (_:105) Vph-ph< threshold = 60.000 V

With the parameter Vph-ph< threshold, you can set the threshold at which the output signal Voltage release is activated when the minimum phase-to-phase voltage falls below this threshold.

Parameter: V2> threshold

- Default setting (_:106) V2> threshold = 4.600 V

With the parameter V2> threshold, you can set the threshold at which the output signal Voltage release is issued when V2 exceeds the threshold.

6.19.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Vseal-in+Vrel#				
_:1	Vseal-in+Vrel#:Mode		• off • on • test	off
_:2	Vseal-in+Vrel#:Operate & flt.rec. blocked		• no • yes	no
_:3	Vseal-in+Vrel#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:6	Vseal-in+Vrel#:Operate delay		0.00 s to 60.00 s	3.00 s
_:10	Vseal-in+Vrel#:Blk. by meas.-volt. failure		• no • yes	yes
_:101	Vseal-in+Vrel#:State of V-seal-in		• off • on	off
_:102	Vseal-in+Vrel#:V seal-in threshold		[illegible] V to 175.000 V	46.200 V
_:104	Vseal-in+Vrel#:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s
_:105	Vseal-in+Vrel#:Vph-ph< threshold		0.300 V to 175.000 V	60.000 V
_:106	Vseal-in+Vrel#:V2> threshold		[illegible] V to 200.000 V	4.600 V

6.19.6.4 Information List

No.	Information	Data Class (Type)	Type
[illegible]			
[illegible]	[illegible]	SPS	I
[illegible]	[illegible]	SPS	I
[illegible]	[illegible]	ENS	O
[illegible]	[illegible]	ENS	O
[illegible]	[illegible]	ENS	O
[illegible]	[illegible]	ACD	O
[illegible]	[illegible]	SPS	O
[illegible]	[illegible]	SPS	O
[illegible]	[illegible]	ACT	O
[illegible]	[illegible]	ACT	O

6.20 Directional Overcurrent Protection, Phases

6.20.1 Overview of Functions

The Directional time-overcurrent protection, phases (ANSI 67):

- Detects short circuits at electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.20.2 Structure of the Function

The Directional time-overcurrent protection, phases function is used in protection function groups. 2 function types are offered:

- Directional time-overcurrent protection, phases - advanced (67 Dir.OC-3ph-A)
- Directional time-overcurrent protection, phases - basic (67 Dir.OC-3ph-B)

The basic function type is provided for standard applications. The function type Advanced offers full functionality, and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 Directional, definite time-overcurrent protection stages and with 1 Directional inverse time-overcurrent protection stage.

In the Advanced function type Directional time-overcurrent protection, phases – advanced, the following stages can be operated simultaneously:

- Maximum of 4 stages Definite time-overcurrent protection – advanced
- 1 stage Inverse time-overcurrent protection – advanced
- 1 stage User-defined overcurrent protection characteristic curve

In the Basic function type Directional time-overcurrent protection, phases – basic the following stages can be operated simultaneously:

- Maximum of 4 stages Definite time-overcurrent protection – basic
- 1 stage Inverse time-overcurrent protection – basic

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The direction determination occurs on a functional level and has the same effects in all stages (see Figure 6-289 and chapter 6.20.7.1 Description). In this way, it is ensured that all stages of a function receive the same direction result. Every stage can be set to the forward or reverse direction.

The group indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- Pickup
- Operate

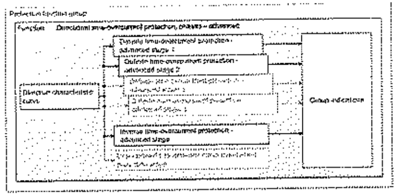

Figure 6-289 Structure/Embedding the Function Directional Time-Overcurrent Protection, Phases - Advanced

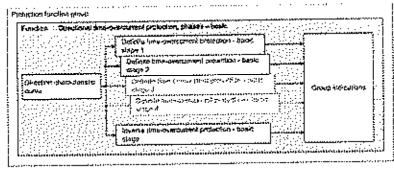

Figure 6-290 Structure/Embedding the Function Directional Time Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with the Inrush-current detection function, the stages can be stabilized against tripping due to transformer-inrush currents.

6.20.3 Stage Control

6.20.3.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.

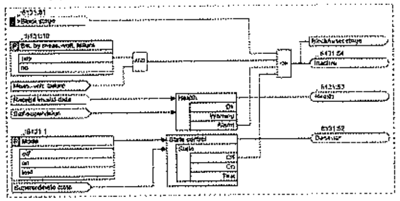

Figure 6-291 Stage Control Logic Diagram

Blocking of the Stage with Measuring-Voltage Failure (Basic and Advanced Stage)

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the Measuring-voltage failure detection function (see chapter 8.3.2.1 Overview of Functions)
- From an external source via the binary input signal >Open of the function block Volt. transf. c. b., which links in the tripping of the voltage transformer circuit breaker

The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.20.3.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:8231:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on
- The binary input signal >Open of the function block VTCB is connected to the voltage-transformer circuit breaker (see chapter 8.3.4.1 Overview of Functions).

Parameter Value	Description
yes	The directional overcurrent protection stage is blocked. Siemens recommends that you retain the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked.

6.20.4 Stage with Definite-Time Characteristic Curve

6.20.4.1 Description

Logic of the Basic Stage

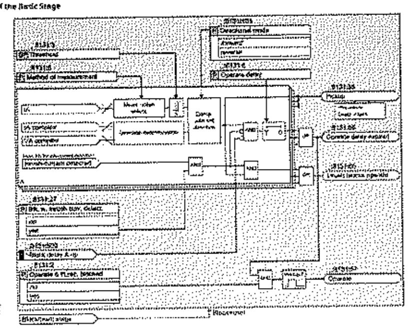

Figure 6-292 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage

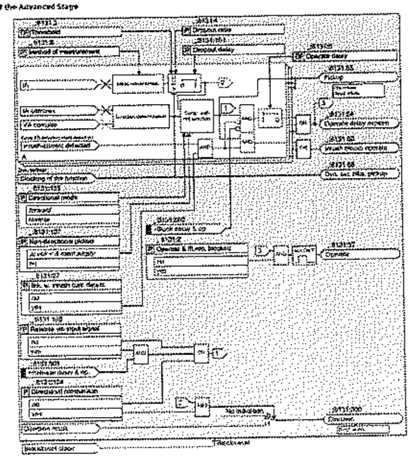

Figure 6-293 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Advanced

Directional mode (Basic and Advanced Stage)

You use the Directional mode parameter to define whether the stage works in a forward or reverse direction.

Direction determination itself works across stages (see section 6.20.7.1 Description).

Non-Directional Pickup, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter 6.20.7.1 Description). If no voltage memory

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ments which can be used to determine the direction are available in the voltage memory, the basic stage generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the Non-directional pickup parameter. With the at volt. < & mem.empty setting, the function picks up in such a situation without direction determination. With the no setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the Directional comparison parameter. With the yes setting, the function uses the threshold value violation to determine the direction (forward or reverse) and reports the indication Direction. The direction indicated is independent of the directional mode set for the stage.

The Release via input signal setting and the >Release delay & op. input signal are available with directional comparison protection. If the Release via input signal parameter is set to yes, the start of the time delay, and therefore the tripping of the stage, are only enabled if the >Release delay & op. input signal is active.

Method of measurement (Basic and Advanced Stage)

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value
  This method of measurement determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Dropout delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal >Block stage (see chapter 6.20.3.1 Description)
- Measuring-voltage failure (see chapter 6.20.3.1 Description)
- Via the dynamic settings function (only provided in the Advanced function type, see chapter Influence of other functions via dynamic settings and chapter 6.16.8.1 Description)

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.16.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.16.8.1 Description.

6.20.4.2 Application and Setting Notes

Parameter: Directional mode

- Default setting (_:8131:105) Directional mode = forward

You use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value (_:8131:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Directional comparison, Release via input signal

- Default setting (_:8131:104) Directional comparison = no
- Default setting (_:8131:106) Release via input signal = no

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the Direction and >Release delay & op. signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the Directional comparison parameter is set to yes, the Release via input signal parameter, the Direction output signal, and the >Release delay & op. input signal become available. If the Release via input signal parameter is set to yes, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the >Release delay & op. input signal is active. The >Release delay & op. input signal must be connected to the release information from the opposite end (forward information from the Direction output signal), see also the application example in chapter 6.20.10 Application Notes for Directional Comparison Protection.

Parameter: Non-directional pickup

- Recommended setting value (_:8131:107) Non-directional pickup = at volt. < & mem.empty

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt. < & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the circuit breaker (CB) trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: Threshold

- Default setting (_:8131:3) Threshold = 1.50 A (for the first stage)

The same considerations apply to setting the threshold value as for non-directional overcurrent protection. For further information, refer to section 6.16.4.2 Application and Setting Notes.

Parameter: Operate delay

- Default setting (_:8131:6) Operate delay = 0.300 s (for the 1st stage)

The Operate delay to be set is derived from the time-grading schedule that has been prepared for the system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

Typical examples of grading times are provided in the chapters 6.20.9 Application Notes for Parallel Lines and 6.20.10 Application Notes for Directional Comparison Protection.

Parameter: Dropout ratio

- Recommended setting value (_:8131:4) Dropout ratio = 0.95

This parameter is not visible in the basic stage.

The recommended set value of 0.95 is appropriate for most applications.

For high-precision measurements, the setting value of the Dropout ratio parameter can be reduced, for example to 0.98. If you expect heavily fluctuating measurands at the response threshold, you can increase the setting value of the Dropout ratio parameter. This avoids chattering of the tripping stage.

Parameter: Dropout delay

- Recommended setting value (_:8131:101) Dropout delay = 0 s

This parameter is not visible in the basic stage.

Siemens recommends using this setting value, since the dropout of a protection stage must be performed as fast as possible.

You can use the Dropout delay parameter ≠ 0 s to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

6.20.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
General				
_:8131:1	Definite-T 1:Mode		• off • on • test	off
_:8131:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8131:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:8131:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8131:107	Definite-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8131:104	Definite-T 1:Directional comparison		• no • yes	no
_:8131:106	Definite-T 1:Release via input signal		• no • yes	no
_:8131:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8131:26	Definite-T 1:Dynamic settings		• no • yes	no
_:8131:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8131:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:8131:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:8131:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:8131:28	Definite-T 1:Effect. by AR off/n.rdy		• no • yes	no
_:8131:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8131:29	Definite-T 1:Affected by AR cycle 1		• no • yes	no
_:8131:36	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8131:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:8131:30	Definite-T 1:Affected by AR cycle 2		• no • yes	no
_:8131:37	Definite-T 1:Stage blocked		• no • yes	no
_:8131:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:8131:31	Definite-T 1:Affected by AR cycle 3		• no • yes	no
_:8131:38	Definite-T 1:Stage blocked		• no • yes	no
_:8131:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:8131:32	Definite-T 1:Affected by AR cycle gr. 3		• no • yes	no
_:8131:39	Definite-T 1:Stage blocked		• no • yes	no
_:8131:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: Cold load PU				
_:8131:33	Definite-T 1:Effect. b. cold load pickup		• no • yes	no
_:8131:40	Definite-T 1:Stage blocked		• no • yes	no
_:8131:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:8131:34	Definite-T 1:Effected by binary input		• no • yes	no
_:8131:41	Definite-T 1:Stage blocked		• no • yes	no
_:8131:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
General				
_:8132:1	Definite-T 2:Mode		• off • on • test	off
_:8132:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:8132:105	Definite-T 2:Directional mode		• forward • reverse	forward
_:8132:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8132:107	Definite-T 2:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8132:104	Definite-T 2:Directional comparison		• no • yes	no
_:8132:106	Definite-T 2:Release via input signal		• no • yes	no
_:8132:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:8132:26	Definite-T 2:Dynamic settings		• no • yes	no
_:8132:27	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8132:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:8132:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:8132:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR off/n.ready				
_:8132:28	Definite-T 2:Effect. by AR off/n.ready		• no • yes	no
_:8132:35	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8132:29	Definite-T 2:Effected by AR cycle 1		• no • yes	no
_:8132:36	Definite-T 2:Stage blocked		• no • yes	no
_:8132:14	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:20	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: AR cycle 2				
_:8132:30	Definite-T 2:Effected by AR cycle 2		• no • yes	no
_:8132:37	Definite-T 2:Stage blocked		• no • yes	no
_:8132:15	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:21	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: AR cycle 3				
_:8132:31	Definite-T 2:Effected by AR cycle 3		• no • yes	no
_:8132:38	Definite-T 2:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8132:16	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:22	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR cycle>3				
_:8132:32	Definite-T 2:Effected by AR cycle gr. 3		• no • yes	no
_:8132:39	Definite-T 2:Stage blocked		• no • yes	no
_:8132:17	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:23	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: Cold load PU				
_:8132:33	Definite-T 2:Effect. b. cold-load pickup		• no • yes	no
_:8132:40	Definite-T 2:Stage blocked		• no • yes	no
_:8132:18	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:24	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: bin.input				
_:8132:34	Definite-T 2:Effected by binary input		• no • yes	no
_:8132:41	Definite-T 2:Stage blocked		• no • yes	no
_:8132:19	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:8132:25	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s

6.20.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation test mode	SPS	I
_:2311:341	General:>Test of direction	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
_:2311:301	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:8131:81	Definite-T 1:>Block stage	SPS	I
_:8131:501	Definite-T 1:>Release delay & op.	SPS	I
_:8131:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:8131:500	Definite-T 1:>Block delay & op.	SPS	I
_:8131:54	Definite-T 1:Inactive	SPS	O
_:8131:52	Definite-T 1:Behavior	ENS	O
_:8131:53	Definite-T 1:Health	ENS	O
_:8131:60	Definite-T 1:Inrush blocks operate	ACT	O
_:8131:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8131:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8131:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:8131:65	Definite-T 1:Dyn.set. ARcycle>3act	SPS	O
_:8131:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:8131:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:8131:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:8131:55	Definite-T 1:Pickup	ACD	O
_:8131:300	Definite-T 1:Direction	ACD	O
_:8131:56	Definite-T 1:Operate delay expired	ACT	O
_:8131:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:8132:81	Definite-T 2:>Block stage	SPS	I
_:8132:501	Definite-T 2:>Release delay & op.	SPS	I
_:8132:84	Definite-T 2:>Activ. dyn. settings	SPS	I
_:8132:500	Definite-T 2:>Block delay & op.	SPS	I
_:8132:54	Definite-T 2:Inactive	SPS	O
_:8132:52	Definite-T 2:Behavior	ENS	O
_:8132:53	Definite-T 2:Health	ENS	O
_:8132:60	Definite-T 2:Inrush blocks operate	ACT	O
_:8132:62	Definite-T 2:Dyn.set. AR cycle1act.	SPS	O
_:8132:63	Definite-T 2:Dyn.set. AR cycle2act.	SPS	O
_:8132:64	Definite-T 2:Dyn.set. AR cycle3act.	SPS	O
_:8132:65	Definite-T 2:Dyn.set. ARcycle>3act	SPS	O
_:8132:66	Definite-T 2:Dyn.set. CLP active	SPS	O
_:8132:67	Definite-T 2:Dyn.set. BI active	SPS	O
_:8132:68	Definite-T 2:Dyn. set. blks. pickup	SPS	O
_:8132:55	Definite-T 2:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:8132:300	Definite-T 2:Direction	ACD	O
_:8132:56	Definite-T 2:Operate delay expired	ACT	O
_:8132:57	Definite-T 2:Operate	ACT	O

6.20.5 Stage with Inverse-Time Characteristic Curve

6.20.5.1 Description

Logic of the Basic Stage

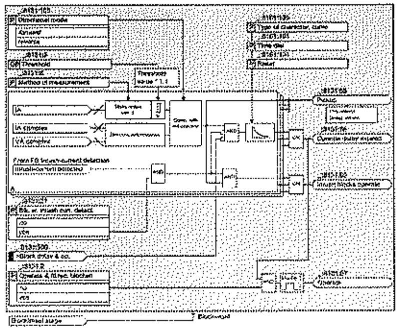

Figure 6-291 Logic Diagram of the Directional, Inverse-Time Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage

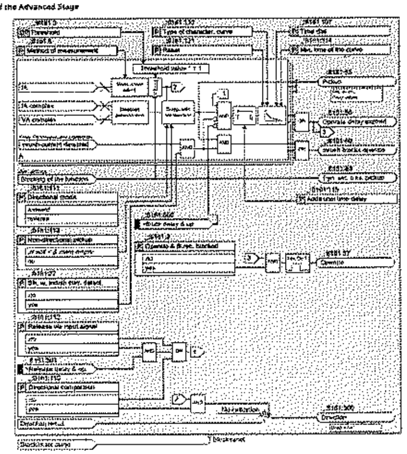

Figure 6-295 Logic Diagram of the Directional, Inverse-Time Overcurrent Protection, Phases - Advanced

Directional mode (Basic and Advanced Stage)

You use the Directional mode parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across stages (see Chapter 6.20.7.1 Description).

Non-directional pickup, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter 6.20.7.1 Description). If no voltage measurements which can be used to determine the direction are available in the voltage memory, the basic stage

generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the Non-directional pickup parameter. With the at volt. < & max. setting, the function picks up in such a situation without direction determination. With the no setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the Directional comparison parameter. With the yes setting, the function uses the threshold value violation to determine the direction (forward or reverse) and reports the indication Direction. The direction indicated is independent of the directional mode set for the stage.

The Release via input signal setting and the >Release delay & op. input signal are available with directional comparison protection. If the Release via input signal parameter is set to yes, the start of the time delay and therefore the tripping of the stage, are only enabled if the >Release delay & op. input signal is active.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Minimum Time of the Curve (Advanced Stage)

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.

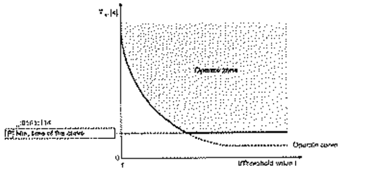

Figure 6-296 Minimum Operating Time of the Curve

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Additional Time Delay (Advanced Stage)

With the parameter Additional time delay, you define a definite time delay in addition to the inverse time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal >Block stage (see chapter 6.20.7.1 Description)
- Measuring-voltage failure (see chapter 6.20.7.1 Description)
- Via the functionality of the dynamic settings (only in the advanced function type, see subtitle Influence of other functions via dynamic settings and chapter 6.16.8.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.16.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.16.8.1 Description.

6.20.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting (_:8161:111) Directional mode = forward

You use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value (_:8161:8) Method of measurement = fundamental comp.

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.

Parameter Value	Description
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Directional comparison, Release via input signal

- Default setting (_:8161:110) Directional comparison = no
- Default setting (_:8161:112) Release via input signal = no

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the Direction and >Release delay & op. signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the Directional comparison parameter is set to yes, the Release via input signal parameter, the Direction output signal, and the >Release delay & op. input signal become available. If the Release via input signal parameter is set to yes, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the >Release delay & op. input signal is active. The >Release delay & op. input signal must be connected to the release information from the opposite end (forward information from the Direction output signal), see also the application example in chapter 6.20.10 Application Notes for Directional Comparison Protection.

Parameter: Non-directional pickup

- Recommended setting value (_:8161:113) Non-directional pickup = at volt.< & mem.empty

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the CB trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: Type of character. curve

- Default setting (_:8161:130) Type of character. curve = IEC normal inverse

The device offers all the usual inverse time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application.

Parameter: Min. time of the curve

- Default setting (_:8161:114) Min. time of the curve = 0.00 s

This parameter is only available in the advanced stage.

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting (_:8161:115) Additional time delay = 0.00 s

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: Threshold

- Default setting (_:8161:3) Threshold = 1.50 A

The same considerations apply to setting the threshold value as for non-directional overcurrent protection. Therefore, refer to chapter 6.16.5.2 Application and Setting Notes for further information.

Parameter: Time dial

- Default setting (_:8161:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.

The set value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system. Where overcurrent protection is used in emergency mode, shorter time delays might be reasonable (one grading time above fast tripping), since the emergency mode only operates if the main protection function fails.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1 (default setting).

Parameter: Reset

- Default setting (_:8161:131) Reset = disk emulation

You use the Reset parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

6.20.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8161:1	Inverse-T 1:Mode		• off • on • test	off
_:8161:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8161:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:8161:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8161:113	Inverse-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8161:110	Inverse-T 1:Directional comparison		• no • yes	no
_:8161:112	Inverse-T 1:Release via input signal		• no • yes	no
_:8161:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8161:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:8161:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8161:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:130	Inverse-T 1:Type of character. curve			
_:8161:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:8161:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:8161:101	Inverse-T 1:Time dial		0.05 to 15.00	1.00
_:8161:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:8161:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8161:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8161:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:8161:36	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8161:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:102	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:8161:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:8161:37	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:103	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:8161:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:8161:38	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:104	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:8161:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8161:39	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:105	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:8161:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8161:40	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8161:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:106	Inverse-T 1:Time dial		0.05 to 15.00	1.00
Dyn.set: Bin.input				
_:8161:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:8161:41	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:107	Inverse-T 1:Time dial		0.05 to 15.00	1.00

6.20.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emg. mode	SPS	I
_:2311:501	General:>Test of direction	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O
_:2311:301	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:8161:81	Inverse-T 1:>Block stage	SPS	I
_:8161:501	Inverse-T 1:>Release delay & op.	SPS	I
_:8161:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:8161:500	Inverse-T 1:>Block delay & op.	SPS	I
_:8161:54	Inverse-T 1:Inactive	SPS	O
_:8161:52	Inverse-T 1:Behavior	ENS	O
_:8161:53	Inverse-T 1:Health	ENS	O
_:8161:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:8161:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8161:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8161:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:8161:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8161:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:8161:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:8161:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O

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No.	Information	Data Class (Type)	Type
_:8161:50	Inverse-T 1:Disk emulation running	SPS	O
_:8161:55	Inverse-T 1:Pickup	ACD	O
_:8161:300	Inverse-T 1:Direction	ACD	O
_:8161:56	Inverse-T 1:Operate delay expired	ACT	O
_:8161:57	Inverse-T 1:Operate	ACT	O

6.20.6 Stage with User-Defined Characteristic Curve

6.20.6.1 Description

The structure of this stage is identical to that of the advanced stage with directional inverse-time characteristic curve (6.20.4.1 Description). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

With the directional, user-defined characteristic curve, you can define the tripping curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

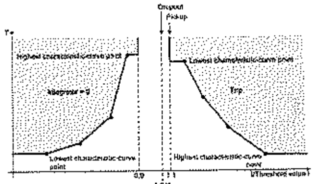


Figure 6-297 Pickup and Dropout Behavior when Using a Directional User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic-curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic curve point.

6.20.6.2 Application and Setting Notes

This stage is structured in the same way as the stage with a directional inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: Current/time value pairs (from the operate curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the Time dial parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

- Default setting (_:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.

The set value for the Time dial parameter is derived from the time grading chart that has been prepared for the electrical power system. Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter set to 1.

Parameter: Reset

- Default setting (_:115) Reset = disk emulation

You use the Reset parameter to define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/time value pairs (of the dropout characteristic curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold value setting afterwards if you want to displace the characteristic curve.

Set the time value in seconds. The characteristic curve is displaced using the Time dial parameter.

NOTE

The value pairs must be entered in continuous order.

6.20.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:110	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Non-directional pickup		• no • at volt. < & mem. empty	at volt. < & mem. empty
_:109	User curve #:Directional comparison		• no • yes	no
_:111	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:115	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.20.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. ARcycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycle>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:300	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.20.7 Direction Determination

6.20.7.1 Description

General

Every phase has a separate direction measuring element. If the threshold value in a phase is exceeded, the direction determination is started for this phase. If there are multiphase short circuits, all measuring elements involved perform direction determination independently. If one of the determined directions matches the set direction, the stage picks up (see descriptions of the stage logic).

The direction is determined by calculating the phase angle between the short-circuit current and a reference voltage.

Measurands for Direction Determining

The directional measuring element uses the short-circuit current of the phase concerned and the cross-polarized phase-to-phase voltage (as the reference voltage) to determine the direction. This means that the direction can still be determined unambiguously and correctly, even if the short-circuit voltages collapse completely when a 1 or 2-phase fault occurs (close-up fault).

The phase-to-phase voltages are calculated when phase-to-ground voltages are connected.

The cross-polarized voltage (reference voltage) is vertical in relation to the short-circuit voltages for 1-phase-to-ground faults (Figure 6-298, left). For 2-phase short circuits, the position of the reference voltages changes up to 30°, depending on the extent to which the short-circuit voltages collapse (Figure 6-298, right).

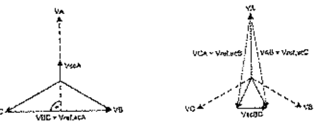


Figure 6-298 Cross-Polarized Voltages for Direction Determination

The following table shows how measurands are assigned for direction-determination purposes in the event of different types of fault.

Table 6-11 Measurands for Direction Determining

Threshold-Value Exceeding	Measuring Element							
	A		B		C		Ground	
	Current	Voltage	Current	Voltage	Current	Voltage	Current	Voltage
A	I_A	V_{BC}	-	-	-	-	-	-
B	-	-	I_B	V_{CA}	-	-	-	-
C	-	-	-	-	I_C	V_{AB}	-	-
Gnd	-	-	-	-	-	-	I_N	V_0
A, Gnd	-	V_{BC}	-	-	-	-	I_N	V_0
B, Gnd	-	-	I_B	V_{CA}	-	-	I_N	V_0
C, Gnd	-	-	-	-	I_C	V_{AB}	I_N	V_0
A, B	I_A	V_{BC}	I_B	V_{CA}	-	-	-	-

B, C			I_C	V_{CA}	I_B	V_{AB}		
A, C	I_A	V_{BC}	-	-	I_B	V_{AB}	-	-
A, B, Gnd	I_A	V_{BC}	I_C	V_{CA}	[illegible]	-	I_C	V_{C}
B, C, Gnd	-	-	I_C	V_{CA}	I_B	V_{AB}	I	V_B
A, C, Gnd	I_A	V_{BC}	-	-	I_B	V_{AB}	I_C	V_C
A, B, C	I_A	V_{BC}	I_C	V_{CA}	I_B	V_{AB}	-	-
A, B, C, Gnd	I_A	V_{BC}	I_C	V_{CA}	I_B	V_{AB}	I_C	V_C

Voltage Memory

Saved voltages are used if, when a 3-pole close-up fault occurs, the measuring voltages are not sufficient for reliable direction determination. Insofar as and as long as no sufficient measuring voltage is available after the storage time (2 s) has elapsed, the detected direction is retained. If the memory does not contain any voltages (when closing onto a short circuit, for example), the behavior of the stage is defined using the Non-directional pickup parameter.

Direction Determination

As mentioned in the General section, the direction is determined by calculating the phase angle between short-circuit current and reference voltage. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (Rotation angle of ref. volt. parameter). This moves the vector of the rotated reference voltage close to the vector of the short-circuit current. Consequently, the result of direction determination is as reliable as possible. Figure 6-299 illustrates the relationship based on a 1-phase ground fault in phase A. The short-circuit current I_{SCA} lags the short-circuit voltage by the short circuit angle φ_{sc}. The reference voltage, in this case V_{BC} for measuring element A, is rotated positively (counterclockwise) by the setting value of the Rotation angle of ref. volt. parameter. In the scenario illustrated here, the rotation is +45°.

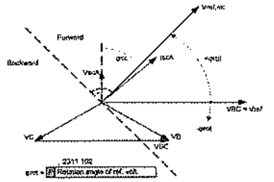


Figure 6-299 Rotation of the Reference Voltage, Phase-Measuring Element

The rotated reference voltage defines the forward and reverse range, see Figure 6-300. The forward range is calculated as ±88° around the rotated reference voltage $V_{ref,rot}$. If the short-circuit current vector is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the backward direction. In the intermediate range, the direction is undetermined.

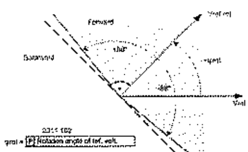


Figure 6-300 Forward Characteristic of the Directional Function, Phase-Measuring Element

Direction Determination for Test Purposes

If you activate the binary input signal >Test of direction, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as current and voltage are greater than approx. 7 % of their secondary rated values.

6.20.7.2 Application and Setting Notes

Parameter: Rotation angle of ref. volt.

- Default setting (_:2311:102) Rotation angle of ref. volt. = 45°

The directional characteristic, that is, the position of the forward and reverse ranges, is set with the Rotation angle of ref. volt. parameter. The short-circuit angle is typically to be found in a range from 30° to 60° inductive. Therefore, in most cases, the default setting of +45° can be retained to position the reference voltage, as it ensures a reliable directional result.

Some example settings for special applications appear in the following (Table 6-12). Please note that for phase-to-ground faults (PG faults), the reference voltage (fault-free voltage) is vertical in relation to the short-circuit voltage. This results in the following setting for the rotation angle:

Rotation angle of ref. volt. = 90 - φsh phase-measuring elements (PG faults)

Please also note that for phase-to-phase faults, the reference voltage is rotated between 0° (distant faults) and 30° (close-up faults) dependent upon the collapse of the faulted voltage (see Figure 6-299). You can take this into account with an average value of 15°:

Rotation angle of ref. volt. = 90 - φsh - 15° phase-measuring elements (PP faults)

Table 6-12 Example settings

Application	φsh typical	Setting Rotation angle of ref. volt.
Power-flow direction; Overhead line; SIPROTEC	60°	Range 30° to 0° for PP faults; Selected: 15°
Power-flow direction; Underground line; SIPROTEC	30°	Range 60° to 30° for PP faults; Selected: 45°
Power-flow direction; Transformer infeed; SIPROTEC; Assuming that underground lines are used; SIPROTEC	30°	Range 60° to 30° for PP faults; Selected: 45°

Input signal: >Test of direction

If you activate the binary input signal >Test of direction, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.20.8 Influence of Other Functions via Dynamic Settings

The influence of these functions via dynamic settings is described in chapter 6.16.8.1 Description and chapter 6.16.8.2 Application and Setting Notes (Advanced Stage).

6.20.9 Application Notes for Parallel Lines

Parallel Lines or Transformers

In parallel lines or transformers with infeed at one end (see Figure 6-301), if there is no directional measuring element, a fault on feeder T1 will also trip the other feeder T2. In contrast, a directional measuring element in the devices on busbar B prevents the tripping of the circuit-breaker in the parallel feeder. Therefore, in Figure 6-301, directional time-overcurrent protection is used in the places marked with direction arrows. Please note that the forward direction of the protection device represents the direction towards the object to be protected. This does not have to be the same as the power direction of normal load flow.

Set time grading in opposition to the load flow with increasing time. As load can only flow in one direction, you can set the direct onal devices without time delay.

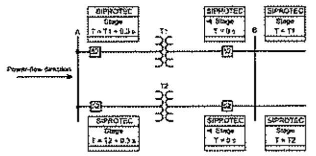


Figure 6-301 Parallel Lines with Transformers

Legend for Figure 6-301
Stage ►: Directional stage, forward direction set
Stage: Non-directional stage
T: Grading time

6.20.10 Application Notes for Directional Comparison Protection

The direction determination of directional time-overcurrent protection can be used to implement directional comparison protection for cable runs with infeed at both ends. Directional comparison protection is used for the selective isolation of a faulted line section (for example, subsections of closed rings). Sections are isolated in fast time, that is, they do not suffer the disadvantage of long grading times.

This technique requires that directional information can be exchanged between the individual protection stations. You can implement this information exchange using a communication channel (protection interface or IEC 61850 GOOSE) or with pilot wires for signal transmission via an auxiliary voltage loop.

Protection Principle

The protection principle is shown in Figure 6-302. 2 devices (one at the start of the line and the other at the end of the line) work together in each line section. The information fault in forward direction is transferred between them. A directional definite time-overcurrent protection level is in operation in both devices in the forward direction (1st level). However, this level is not enabled in the idle state. The level is only released when the information fault in forward direction is received from the opposite end. If the enabled level also defines the fault in the forward direction, the fault must be on this line section and the level trips immediately. As this protection principle works with an enable procedure (and not with a blocking procedure), there is no need to delay the level.

A second directional definite time-overcurrent protection stage with standard time grading works in parallel with the first stage as a selective backup stage. This ensures full selectivity of protection in the following situations:

- Infeed at one end or weak infeed at one end: in this case, no release signal is generated.
- Failure of the communication route: in this case, the release signal is not transmitted.

To provide selective protection in fast time for busbars between the line sections also, you can combine this protection principle with the principle of reverse interlocking. This principle is not discussed in further detail in this document.

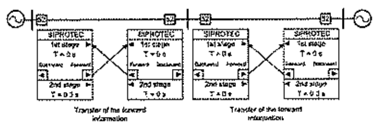


Figure 6-302 Selectivity through Directional Comparison Protection

Legend for Figure 6-302
Stage ►: Stage is set in the forward direction; stage 1 is instantaneous, stage 2 is graded
►, ◄: If a threshold value is exceeded, the stage indicates the direction (forward or reverse)

If you are using a communication channel, the protocol transmission methods detect if the channel is interrupted. If you are using pilot wires, we recommend operation based on a closed-circuit connection. The device uses a function chart to check and indicate if the binary input is dead for an unexpectedly long period. In contrast with the blocking procedure, overfunction is not possible if communication is lost. Therefore, a loss of communication is not critical where this procedure is concerned, although it must be detected and indicated.

Directional comparison protection can also be implemented as a blocking procedure. This procedure works under all system switching states, i.e. also with infeed at one end (or weak infeed). However, to use it you must delay the stage (typically by 100 ms) so that the blocking signal is received in time under all circumstances. It is also essential that you monitor the communication channel to avoid overfunction in the event of failure (followed by a system incident).

Configuration of the Stage, Function Chart

To configure the stage, proceed as follows:

- The Directional mode parameter of both stages must be set to forward.
- The Directional comparison and Release via input signal parameters of the first stage must be set to yes. This ensures that the first stage is only released if the >Release delay & op. input signal is active. Furthermore, the direction is indicated if a threshold value is exceeded.
- The first stage can be set without a time delay. The second stage has to be graded.
- The information forward from the protection signal in the first stage must be transmitted to the opposite end. The routing is determined by the type of transmission.
- A function chart has to be implemented at the receive end to link the received forward information and release signals, dependent upon the type of transmission.

6.21 Directional Overcurrent Protection, Ground

6.21.1 Overview of Functions

The Directional time-overcurrent protection, ground function (ANSI 67N):

- Detects short circuits to ground affecting electric equipment
- Ensures selective ground fault detection for parallel lines or transformers with infeed at one end
- Ensures selective ground fault detection in cable runs with infeed at both ends or in rings connected to form ring topologies

6.21.2 Structure of the Function

The Directional time-overcurrent protection, ground function can be used in protection function groups which provide zero-sequence current and zero-sequence voltage measurements. 2 function types are offered:

- Directional time-overcurrent protection, ground – advanced (67N Dir.OC-gnd-A)
- Directional time-overcurrent protection, ground – basic (67N Dir.OC-gnd-B)

The basic function type shall be used for standard applications. The advanced function type provides more functionalities and is intended for more sophisticated applications.

Both function types are preconfigured by the manufacturer with 2 Definite time-overcurrent protection stages and 1 Inverse time-overcurrent protection stage.

In the advanced function type Directional time-overcurrent protection, ground – advanced, the following stages can operate simultaneously:

- A maximum of 4 Definite time-overcurrent protection – advanced stages
- 1 Inverse time-overcurrent protection – advanced stage
- 1 Logarithmic inverse time-overcurrent protection stage
- 1 Logarithmic inverse time with knee-point overcurrent protection stage
- 1 User-defined characteristic curve overcurrent protection stage

In the basic function type Directional time-overcurrent protection, ground – basic, the following stages can operate simultaneously:

- A maximum of 4 Definite time-overcurrent protection – basic stages
- 1 Inverse time-overcurrent protection – basic stage

Referring to Figure 6-303 and Figure 6-304, the stages not preconfigured are shown in gray. Apart from the operate-delay characteristic curve, the stages are similar in structure.

The general functionality includes the direction determination and the measured-value selection (only advanced function). They take place on the functional level and have a uniform effect on the stages (see Figure 6-303 and chapter General Functionality). This ensures that all stages of the function receive the same measured current value and the same direction result. Each stage can be set to work in forward or reverse direction.

The group indication output logic generates the following group indications for the protection function by the logic OR from the stage-selective indications:

- Pickup
- Operate

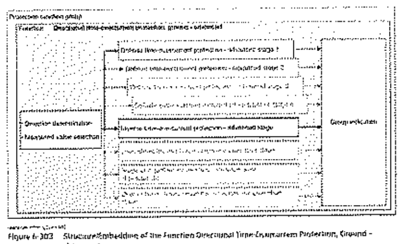


Figure 6-303 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Advanced

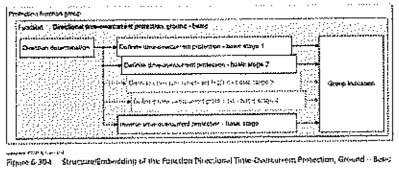


Figure 6-304 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Basic

If the following listed device-internal functions are present in the device, these functions can influence the pickup values and operate delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with the inrush-current detection function, the stages can be stabilized against operate due to transformer-inrush currents.

6.21.3 General Functionality

6.21.3.1 Measured Value Selection

Logic

The function provides the option to select between the values IN measured or 3I0 calculated.

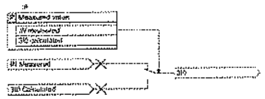


Figure 6-305 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types 3-phase + IN and 3-phase + IN-separate. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

Table 6-53 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.010 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.010 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.010 A to 35.000 A	0.15 A to 175.00 A	0.010 A to 35.000 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.21.3.2 Direction Determination

Logic of Direction Determination

The following figure represents the logic of the direction determination. It applies to all types of stages.

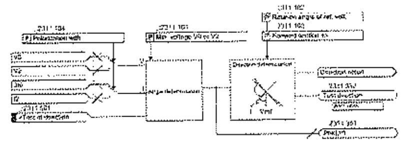


Figure 6-306 Logic Diagram of Direction Determination

Measurand for the Direction Determination

With the parameter Polarization with you define whether the direction determination is calculated with the zero-sequence components 3I0 and V0 or with the negative-sequence components I2 and V2, which are present during faults in the network.

The angle between 3I (= -3I0) and V0 (respectively -I2 and V2) in case of using the negative-sequence components is available as a functional measured value. This value is only present during faults in the network.

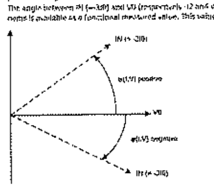


Figure 6-307 Measured-Value Definition

Start of the Direction Determination

If the zero-sequence current 3I0 exceeds the pickup threshold of a stage and the selected voltage (V0 or V2) exceeds the parameter Min. voltage V0 or V2 as well, the direction determination is started.

Direction Determination with Zero-Sequence Values

The direction is determined by calculating the phase angle between the short-circuit current -3I0 and the rotated reference voltage Vref, rot. Contrary to the Directional time-overcurrent protection, phase function, which works with the healthy voltage as reference voltage, the fault voltage V0 itself is the reference voltage for the Directional time-overcurrent protection, ground function. To take different system condi-

tions and applications into account, the reference voltage V0 can be rotated through an adjustable angle (parameter Rotation angle of ref. volt.). This moves the vector of the rotated reference voltage close to the vector of the short circuit current -3I0. Consequently, the result of direction determination is as reliable as possible. Figure 6-308 illustrates the relationship based on a 1-phase-to-ground fault in phase A. The fault current has a phase displacement of 180° to the fault current IscA and lags the fault voltage by the fault angle φsc. The reference voltage V0 is rotated by φrot which is -45°.

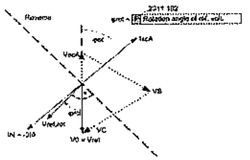


Figure 6-308 Rotation of the Reference Voltage, Directional Time-Overcurrent Protection, Ground Function with Zero-Sequence Values

The rotated reference voltage Vref, rot and the parameter Forward section +/- define the forward and reverse ranges, see Figure 6-309. The forward range is calculated as ± Δφ° around the rotated reference voltage Vref, rot. Δφ is set with the parameter Forward section +/-. If the short-circuit current vector -3I0 is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the reverse direction. In the intermediate range, the direction is undetermined.

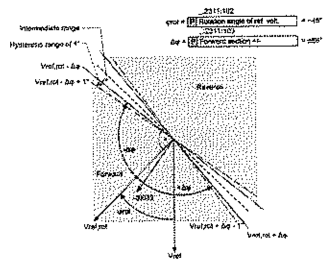


Figure 6-309 Forward/Reverse Characteristic of the Directional Time-Overcurrent Protection, Ground Function

Direction Determination with Negative-Sequence Values

The method works in the same way as for zero-sequence values. Instead of 3I0 and V0, the negative-sequence values I2 and V2 are used for determining the direction.

Direction Determination for Test Purposes

If you activate the binary input signal >Test of direction, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as the zero-sequence current 3I0 and the zero-sequence voltage V0 exceeds approx. 7 % of the secondary rated values of phase current and voltage.

6.21.3.3 Application and Setting Notes

Parameter: Measured value

- Recommended setting value (_:19) Measured value = IN measured

This parameter is not available in the basic function.

Parameter Value	Description
IN measured	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
3I0 calculated	The function operates with the calculated zero-sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

Parameter: Min. voltage V0 or V2

- Recommended setting value (_:2311:101) Min. voltage V0 or V2 = 2 V

This parameter is not available in the basic function. The basic function uses a fixed value of 2 V.

You use the Min. voltage V0 or V2 parameter to define the minimum zero-sequence voltage or negative-sequence voltage for the direction determination. The minimum voltage must be set greater than the maximum operational unbalance plus the voltage-transformer measuring errors.

As the measuring error of the individual voltage transformer is not added up, the critical measuring-error influence is the unbalance of the primary system.

Siemens recommends observing the operational zero-sequence voltage V0 of the protected object (for example, the line) via the operational measured values of the device and providing the maximum value with a certainty of 50 %.

> **EXAMPLE**
>
> Maximum operational measured value of zero-sequence voltage V0 = 0.5 Vsec
>
> Min. voltage V0 or V2 = 1.5 * 0.5 V = 0.75 Vsec

If you have no information about maximum operational unbalance, Siemens recommends using the default setting.

Parameter: Rotation angle of ref. volt., Forward section +/-

- Recommended setting value (_:2311:102) Rotation angle of ref. volt. = -45°
- Recommended setting value (_:2311:103) Forward section +/- = 88°

The parameter Forward section +/- is not available in the basic function. The basic function uses a fixed value of 88°.

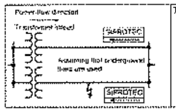
The direction characteristic, that is, the area of the forward and reverse ranges, is set with the Rotation angle of ref. volt. and the Forward section +/- parameters. The short-circuit angle is typically to be found in a range from -30° to -60° inductively. Therefore, in most cases, the default setting of -45° can be retained to position the reference voltage, as it ensures a reliable directional result.

Some example settings for special applications appear below Table 6-14. Note that for 1-phase-to-ground faults (PG faults), the reference voltage is the zero-sequence voltage V0. This results in the following setting for the rotation angle.

Rotation angle of ref. volt. = -φk ground measuring elements (PG faults)

Table 6-14 Example Settings

Application	φk Typical	Setting Rotation angle of ref. volt.
Power-flow direction; Overhead line; SIPROTEC	60°	-60°
Power-flow direction; Underground line; SIPROTEC	30°	-30°

	3I0	3I0

Parameter: Polarization with

- Recommended setting value (_:2311:104) Polarization with = zero sequence

This parameter is not available in the basic function. The basic function uses always zero-sequence components for the direction determination.

You use the parameter Polarization with to select the values for the direction determination.

Parameter Value	Description
zero sequence	Select zero sequence to determine the direction via the zero-sequence components V0 and 3I0. Siemens recommends using the zero-sequence components for the direction determination.
negative sequence	Select negative sequence to determine the direction via the negative-sequence components V2 and I2. The negative-sequence system can be used in case of danger that the zero-sequence voltage is too small due to unfavorable zero-sequence impedance conditions or that a parallel line influences the zero-sequence system.

Input Signal: >Test of direction

If you activate the binary input signal >Test of direction, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.21.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:9	General:Measured value		• 3I0 calculated • IN measured	IN measured
_:101	General:Min. voltage V0 or V2		0.150 V to 20.000 V	2.000 V
_:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °
_:103	General:Forward section +/-		0 ° to 90 °	88 °
_:104	General:Polarization with		• zero sequence • negative sequence	zero sequence

6.21.3.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:>Test of direction		I
_:2311:302	General:Test direction		O
_:2311:351	General:Phi(I,V)		O

6.21.4 Stage Control

6.21.4.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.

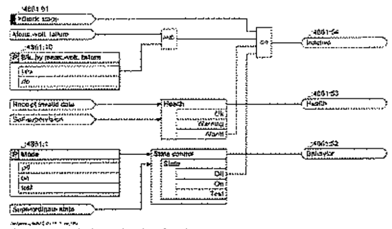


Figure 6-310 Logic Diagram of the Stage Control

Blocking of Stage in Case of Measuring-Voltage Failure

The stages can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stages:

- From an internal source on the pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Voltage-transformer circuit breaker, which links to the trip of the voltage-transformer circuit breaker

The Blk. by meas.-volt. failure parameter can be set to either block or not block the stage when the Measuring-voltage failure detection function picks up.

6.21.4.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:4861:10) Blk. by meas.-volt. failure = yes

You can use the Blk. by meas.-volt. failure parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal Measuring-voltage failure detection function is configured and switched on.
- The binary input signal >Open of the function block Voltage-transformer circuit breaker is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The directional overcurrent protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.

6.21.5 Stage with Definite-Time Characteristic Curve

6.21.5.1 Description

Logic of the Basic Stage

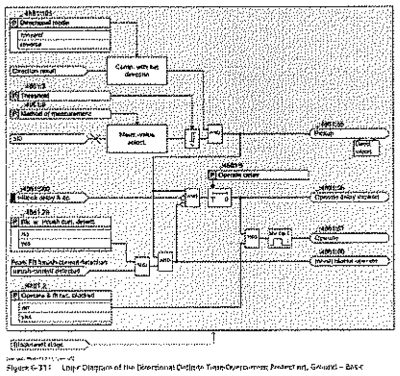


Figure 6-311 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage

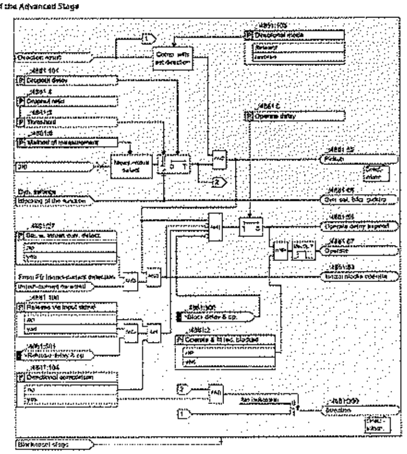


Figure 6-312 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting Connection type of the Measuring point I-3ph, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 threshold range varies according to the following table.

Table 6-15 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
3-phase + IN 3-phase + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

- Measurement of the fundamental component:
  This measuring procedure processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value
  This measuring procedure determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Directional Mode (Basic and Advanced Stage)

You can use the Directional mode parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see chapter 6.21.3.2 Direction Determination).

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal >Block stage (see chapter 6.21.4.1 Description)
- Measuring-voltage failure (see chapter 6.21.4.1 Description)
- Via the dynamic settings functionality (only available in the advanced function type, see Influence of Other Functions via Dynamic Settings and chapter 6.21.10 Influence of Other Functions via Dynamic Settings)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.17.7.1 Description.

Dropout Delay (Advanced Stage)

In case of undershooting of the dropout threshold, the dropout can be delayed. The pickup is maintained for the specified time. The operate delay continues to run. If the operate delay expires while the pickup is still maintained, the stage operates.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the Directional comparison parameter. With the yes setting, the direction indication Direction is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage; the direction indicated is independent of the directional mode set for the stage.

The Release via input signal parameter and the >Release delay & op. input signal are available with directional comparison protection. If the Release via input signal parameter is set to yes, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the >Release delay & op. input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.21 Influence of Other Functions via Dynamic Settings.

6.21.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting (_:4861:105) Directional mode = forward

You can use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value (_:4861:8) Method of measurement = fundamental comp.

You can use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: Directional comparison, Release via input signal

- Default setting (_:4861:104) Directional comparison = no
- Default setting (_:4861:106) Release via input signal = no

The parameters Directional comparison and Release via input signal are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the Direction and >Release delay & op. signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the Directional comparison parameter is set to yes, the Release via input signal parameter, the Direction output signal, and the >Release delay & op. input signal become available. If the Release via input signal parameter is set to yes, the start of the operate delay and operate signal are only enabled when the >Release delay & op. input signal is active. The >Release delay & op. input signal must be connected to the suitable information from the opposite end (forward information from the Direction output signal). See also the application example in chapter 6.20.10 Application Notes for Directional Comparison Protection.

Parameter: Dynamic settings

- Default setting (_:4861:26) Dynamic settings = no

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (Automatic reclosing or Cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to yes. This makes the configuration parameters Effected by Auto reclosing/Cold-load PU/Binary input as well as the dynamic settings Threshold, Operate delay, and Stage blocked of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter 6.17.4.3 Application and Setting Notes (Advanced Stage) of the function Overcurrent Protection, Ground.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:4861:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Threshold

- Default setting (_:4861:3) Threshold = 1.50 A

For setting the threshold value, the same considerations apply as for the non-directional time-overcurrent protection function.

For further information, refer to chapter 6.17.4.2 Application and Setting Notes.

Parameter: Dropout ratio

- Recommended setting value (_:4861:4) Dropout ratio = 0.95

This parameter is not visible for the basic stage.

The recommended setting value of 0.95 is appropriate for most applications.

For high-precision measurements, the setting value of the Dropout ratio parameter can be reduced, for example to 0.98. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the Dropout ratio parameter. This avoids chattering of the stage.

Parameter: Dropout delay

- Recommended setting value (_:4861:101) Dropout delay = 0 s

This parameter is not visible for the basic stage.

Siemens recommends using the dropout delay of 0 s, since the dropout of a protection stage must be performed as fast as possible.

You can use the Dropout delay parameter ≠ 0 s to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical data) and set the result.

Parameter: Operate delay

- Default setting (_:4861:6) Operate delay = 0.300 s (for the 1st stage)

The Operate delay to be set is derived from the time-grading chart that has been prepared for the system.

Typical examples of grading times are provided in sections 6.20.9 Application Notes for Parallel Lines and 6.20.10 Application Notes for Directional Comparison Protection.

6.21.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4861:1	Definite-T 1:Mode		• off • on • test	off
_:4861:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4861:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:4861:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4861:104	Definite-T 1:Directional comparison		• no • yes	no
_:4861:106	Definite-T 1:Release via input signal		• no • yes	no
_:4861:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4861:26	Definite-T 1:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4861:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:4861:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:4861:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:4861:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4861:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4861:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:4861:36	Definite-T 1:Stage blocked		• no • yes	no
_:4861:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:4861:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:4861:37	Definite-T 1:Stage blocked		• no • yes	no
_:4861:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:4861:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:38	Definite-T 1:Stage blocked		• no • yes	no
_:4861:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:4861:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4861:39	Definite-T 1:Stage blocked		• no • yes	no
_:4861:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:4861:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4861:40	Definite-T 1:Stage blocked		• no • yes	no
_:4861:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: Bin. input				
_:4861:34	Definite-T 1:Effected by binary input		• no • yes	no
_:4861:41	Definite-T 1:Stage blocked		• no • yes	no
_:4861:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4862:1	Definite-T 2:Mode		• off • on • test	off
_:4862:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:4862:105	Definite-T 2:Directional mode		• forward • reverse	forward
_:4862:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4862:104	Definite-T 2:Directional comparison		• no • yes	no
_:4862:106	Definite-T 2:Release via input signal		• no • yes	no
_:4862:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:4862:26	Definite-T 2:Dynamic settings		• no • yes	no
_:4862:27	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:4862:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:4862:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:4862:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR off/n.rdy				
_:4862:28	Definite-T 2:Effect. by AR off/n.ready		• no • yes	no
_:4862:35	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4862:29	Definite-T 2:Effected by AR cycle 1		• no • yes	no
_:4862:36	Definite-T 2:Stage blocked		• no • yes	no
_:4862:14	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:20	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s

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Addr.	Parameter	C	Setting Options	Default Setting
Dyn.sets: AR cycle 2				
_:4862:30	Definite-T 2:Affected by AR cycle 2		• no • yes	no
_:4862:37	Definite-T 2:Stage blocked		• no • yes	no
_:4862:15	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:21	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.sets: AR cycle 3				
_:4862:31	Definite-T 2:Affected by AR cycle 3		• no • yes	no
_:4862:38	Definite-T 2:Stage blocked		• no • yes	no
_:4862:16	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:22	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: AR cycle>3				
_:4862:32	Definite-T 2:Affected by AR cycle gr. 3		• no • yes	no
_:4862:39	Definite-T 2:Stage blocked		• no • yes	no
_:4862:17	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:23	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.s: Cold load PU				
_:4862:33	Definite-T 2:Effect. b. cold-load pickup		• no • yes	no
_:4862:40	Definite-T 2:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4862:18	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:24	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: Bin.input				
_:4862:34	Definite-T 2:Affected by binary input		• no • yes	no
_:4862:41	Definite-T 2:Stage blocked		• no • yes	no
_:4862:19	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4862:25	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s

6.21.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:352	General:Test direction	ACD	O
_:2311:351	General:Phi(I,V)	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:4861:81	Definite-T 1:>Block stage	SPS	I
_:4861:501	Definite-T 1:>Release delay & op.	SPS	I
_:4861:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:4861:500	Definite-T 1:>Block delay & op.	SPS	I
_:4861:54	Definite-T 1:Inactive	SPS	O
_:4861:52	Definite-T 1:Behavior	ENS	O
_:4861:53	Definite-T 1:Health	ENS	O
_:4861:60	Definite-T 1:Inrush blocks operate	SPS	O
_:4861:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4861:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4861:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4861:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:4861:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:4861:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:4861:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O

No.	Information	Data Class (Type)	Type
_:4861:55	Definite-T 1:Pickup	ACD	O
_:4861:300	Definite-T 1:Direction	ACD	O
_:4861:56	Definite-T 1:Operate delay expired	ACT	O
_:4861:57	Definite-T 1:Operate	ACT	O

6.21.6 Stage with Inverse-Time Characteristic Curve

6.21.6.1 Description

Logic of the Basic Stage

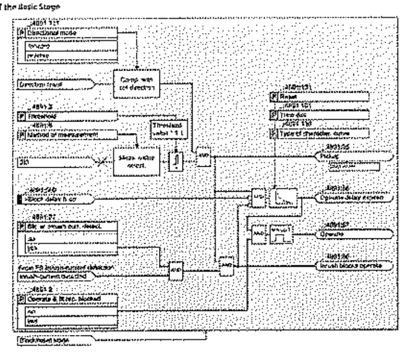

Figure 6-313 Logic Diagram of the Directional Inverse-Time Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage

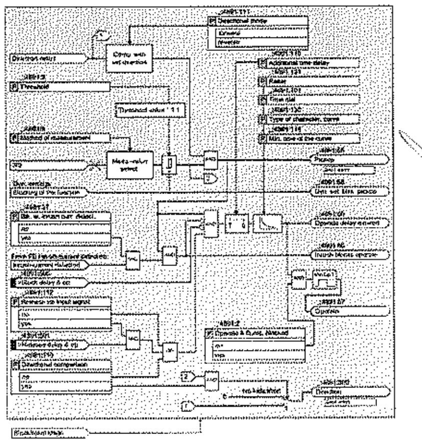

Figure 6-314 Logic Diagram of the Directional Inverse-Time Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the Measuring point I-3ph, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 Threshold range varies according to the following table.

Table 6-16 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
3ph + IN 3ph + IN-separate	Measured	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

- Measurement of the fundamental component:
  This measuring procedure processes the sampled current values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This measuring procedure determines the current amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Directional Mode (Basic and Advanced Stage)

You can use the Directional mode parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see chapter 6.21.3.2 Direction Determination).

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve According to IEC and ANSI (Basic and Advanced Stage)

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed. An integrated measuring procedure totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the threshold value by a factor of 1.045 (0.95 x 1.1x threshold value), the dropout starts. The pickup will be indicated as clearing. You can influence the dropout behavior via adjustable parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical data.

Minimum Time of the Curve (Advanced Stage)

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.

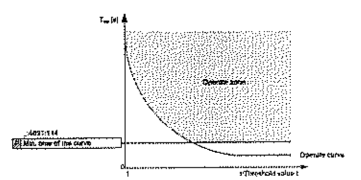

Figure 6-315 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter Additional time delay, you define a definite time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal >Block stage (see chapter 6.21.4.1 Description)
- Measuring-voltage failure (see chapter 6.21.4.1 Description)
- Via the dynamic settings functionality (only available in the advanced function type, see Influence of Other Functions via Dynamic Settings and chapter 6.21.10 Influence of Other Functions via Dynamic Settings)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter Blocking of the Tripping by Device Internal Inrush Current Detection.

For more information, refer to 6.21.7.1 Description.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the Directional comparison parameter. With the yes setting, the direction indication Direction is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indicated is independent of the directional mode set for the stage.

The Release via input signal parameter and the >Release delay & op. input signal are available with directional comparison protection. If the Release via input signal parameter is set to yes, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the >Release delay & op. input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.21.10 Influence of Other Functions via Dynamic Settings.

6.21.6.2 Application and Setting Notes

Parameter: Directional mode

- Default setting (_:4891:111) Directional mode = forward

You can use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value (_:4891:8) Method of measurement = fundamental comp.

You can use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: Directional comparison, Release via input signal

- Default setting (_:4891:110) Directional comparison = no
- Default setting (_:4891:112) Release via input signal = no

The parameters Directional comparison and Release via input signal are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the Directional and >Release delay & op. signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the Directional comparison parameter is set to yes, the Release via input signal parameter, the Directional output signal, and the >Release delay & op. input signal become available. If the Release via input signal parameter is set to yes, the start of the operate delay and operate signal are only enabled when the >Release delay & op. input signal is active. The >Release delay & op. input signal must be connected to the reverse information from the opposite end (forward information from the Directional signal). See also the application example in chapter 6.21.10 Application Notes for Directional Comparison Protection.

Parameter: Dynamic settings

- Default setting (_:4891:26) Dynamic settings = no

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (Automatic reclosing or Cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to yes. This makes the configuration parameters Effected by AR cycle/Cold-load PU/Binary input as well as the dynamic settings Threshold, Time dial, and Stage blocked of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter 6.17.6.2 Application and Setting Notes (Advanced Stage) of the function Overcurrent Protection, Ground.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:4891:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage V_{sc} of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Min. time of the curve

- Default setting (_:4891:114) Min. time of the curve = 0.00 s

This parameter is only available in the advanced stage.

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of the inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

> **NOTE**
> If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting (_:4891:115) Additional time delay = 0.00 s

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: Threshold

- Default setting (_:4891:3) Threshold = 1.20 A

The setting depends on the minimal occurring ground-fault current. This must be detected.

Consider that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the Threshold.

Parameter: Type of character. curve

- Default setting (_:4891:130) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application.

Parameter: Time dial

- Default setting (_:4891:101) Time dial = 1

You can use the Time dial parameter to displace the characteristic curve in the time direction.

The setting value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1 (default setting).

Parameter: Reset

- Default setting (_:4891:131) Reset = disk emulation

You can use the Reset parameter setting to define whether the stage decreases according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Select this setting if the dropout does not have to be performed after a disk emulation and an instantaneous dropout is desired instead.

6.21.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4891:1	Inverse-T 1:Mode		• off • on • test	off
_:4891:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4891:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:4891:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4891:110	Inverse-T 1:Directional comparison		• no • yes	no
_:4891:112	Inverse-T 1:Release via input signal		• no • yes	no
_:4891:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4891:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:4891:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4891:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:130	Inverse-T 1:Type of character. curve			
_:4891:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:4891:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:4891:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:4891:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: AR off/n.rdy				
_:4891:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4891:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4891:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:4891:36	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:4891:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:4891:37	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:4891:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:4891:38	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:4891:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4891:39	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4891:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:4891:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4891:40	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:4891:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:4891:41	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.21.6.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T 1			
_:4891:81	Inverse-T 1:>Block stage	SPS	I
_:4891:501	Inverse-T 1:>Release delay & op.	SPS	I
_:4891:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:4891:500	Inverse-T 1:>block delay & op.	SPS	I
_:4891:54	Inverse-T 1:Inactive	SPS	O
_:4891:52	Inverse-T 1:Behavior	ENS	O
_:4891:53	Inverse-T 1:Health	ENS	O
_:4891:60	Inverse-T 1:Inrush blocks operate	SPS	O
_:4891:61	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4891:62	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4891:63	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4891:64	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O

No.	Information	Data Class (Type)	Type
_4891:66	Inverse-T 1:Dyn.set. AR cycle1	SPS	O
_4891:67	Inverse-T 1:Dyn.set. AR cycle2	SPS	O
_4891:68	Inverse-T 1:Dyn.set. CLP active	SPS	O
_4891:59	Inverse-T 1:Disk emulation running	SPS	O
_4891:55	Inverse-T 1:Pickup	ACD	O
_4891:300	Inverse-T 1:Direction	ACD	O
_4891:56	Inverse-T 1:Operate delay expired	ACT	O
_4891:57	Inverse-T 1:Operate	ACT	O

6.21.7 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

6.21.7.1 Description

Logic of the Stage

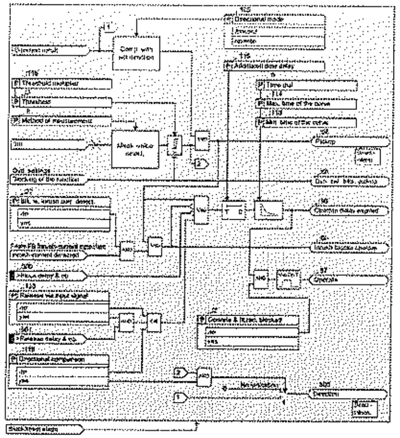

Figure 6-316 Logic Diagram of the Directional Logarithmic Inverse Time-Overcurrent Protection, Ground

Apart from the operate curve, this type of stage is identical to the inverse time-overcurrent protection – advanced stage (see chapter 6.21.6.1 Description).

This section will only discuss the nature of the operate curve. For further functionality, refer to chapter 6.21.6.1 Description.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the pickup value. An integrator accumulates the value $1/T_{op}$. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following figure. The Threshold multiplier parameter defines the beginning of the characteristic curve. The Max. time of the curve determines the initial value of the characteristic curve. The Time dial parameter changes the slope of the characteristic curve. At high currents, the Min. time of the curve parameter indicates the lower time limit.

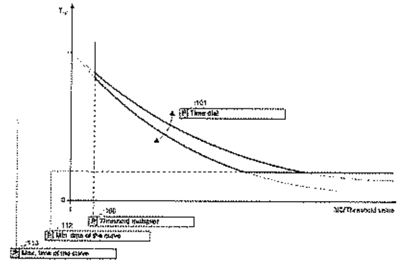

Figure 6-317 Operate Curve of Logarithmic Inverse-Time Characteristic

The time to operate is calculated with the following formula.

$$T_{op} = T_{max} - T_d \ln\left(\frac{3I0}{I_{thresh} \cdot I_{mul}}\right)$$

Where

T_{max}	Maximum time of the curve (parameter Max. time of the curve)
T_d	Time dial (parameter Time dial)
T_{op}	Operate time
3I0	Measured zero-sequence current
I_{thresh}	Threshold value (parameter Threshold)
I_{mul}	Threshold multiplier (parameter Threshold multiplier)

If the calculated time is less than T_{min} (parameter Min. time of the curve), T_{min} is used.

6.21.7.2 Application and Setting Notes

Apart from the operate curve, this type of stage is identical to the ground-fault protection type with inverse-time delay according to IEC and ANSI (advanced function type) (see chapter 6.21.6.1 Description).

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 6.21.6.2 Application and Setting Notes.

Stage Type Selection

If the operate delay is to be dependent on the current level according to a logarithmic characteristic curve, select this stage type.

Dynamic Settings: Threshold

- Default setting (_:3) Threshold = 1.20 A

Define the pickup value corresponding to the application. In doing so, for time-graded stages, the settings of the superordinate and of the subordinate stages in the time grading chart must be taken into consideration.

Parameter: Threshold multiplier

- Default setting (_:116) Threshold multiplier = 1.1

You can use the Threshold multiplier parameter to define the beginning of the characteristic curve on the current axis (in relation to the threshold value).

General information cannot be provided. Define the value corresponding to the application.

EXAMPLE

Threshold (Secondary current)	I_{thresh} = 1.2 A
Threshold multiplier	I_{mul} = 1.1
Pickup value (Secondary current)	I_{pu} = 1.2 A · 1.1 = 1.32 A

Dynamic Settings: Time dial

- Default setting (_:6) Time dial = 1.250 s

You can use the Time dial parameter to change the slope of the characteristic curve.

General information cannot be provided. Define the value corresponding to the application.

Parameter: Max. time of the curve

- Default setting (_:114) Max. time of the curve = 5.800 s

The parameter Max. time of the curve determines the initial value of the characteristic curve (for 3I0 = Threshold).

General information cannot be provided. Define the value corresponding to the application.

Parameter: Min. time of the curve

- Default setting (_:113) Min. time of the curve = 1.200 s

The parameter Min. time of the curve determines the lower time limit (at high currents).

General information cannot be provided. Define the value corresponding to the application.

Parameter: Additional time delay

- Recommended setting value (_:115) Additional time delay = 0 s

You can set an additional current-independent time delay. This additional delay is intended for special applications.

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Siemens recommends setting this time to 0 s so that it has no effect.

6.21.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Log. inv. T #:Mode		• off • on • test	off
_:2	Log.-inv.-T #:Operate & flt.rec. blocked		• no • yes	no
_:119	Log.-inv.-T #:Directional mode		• forward • reverse	forward
_:8	Log. inv. T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp
_:118	Log.-inv.-T #:Directional comparison		• no • yes	no
_:110	Log.-inv.-T #:Release via input signal		• no • yes	no
_:10	Log. inv. T #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	Log.-inv.-T #:Dynamic settings		• no • yes	no
_:27	Log.-inv.-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	Log. inv. T #:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:6	Log.-inv.-T #:Time dial		0,000 s to 60,000 s	1,250 s
_:113	Log.-inv. T #:Min. time of the curve		0,000 s to 60,000 s	1,200 s
_:114	Log.-inv.-T #:Max. time of the curve		0,000 s to 60,000 s	5,800 s
_:116	Log. inv. T #:Threshold multiplier		1,00 to 4,00	1,10
_:115	Log.-inv.-T #:Additional time delay		0,000 s to 60,000 s	0,000 s
Dyn.s: AR off/n.rdy				
_:28	Log.-inv.-T #:Effect. by AR off/n.ready		• no • yes	no
_:35	Log. inv. T #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	Log.-inv.-T #:Effected by AR cycle 1		• no • yes	no
_:36	Log. inv. T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:14	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:107	Log. inv. T #:Time dial		0,000 s to 60,000 s	1,250 s
Dyn.sets: AR cycle 2				
_:30	Log.-inv.-T #:Effected by AR cycle 2		• no • yes	no
_:37	Log.-inv.-T #:Stage blocked		• no • yes	no
_:15	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:108	Log.-inv.-T #:Time dial		0,000 s to 60,000 s	1,250 s
Dyn.sets: AR cycle 3				
_:31	Log.-inv.-T #:Effected by AR cycle 3		• no • yes	no
_:38	Log. inv. T #:Stage blocked		• no • yes	no
_:16	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:109	Log.-inv.-T #:Time dial		0,000 s to 60,000 s	1,250 s
Dyn.s: AR cycle>3				
_:32	Log.-inv.-T #:Effected by AR cycle gr. 3		• no • yes	no
_:39	Log.-inv. T #:Stage blocked		• no • yes	no
_:17	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:110	Log. inv. T #:Time dial		0,000 s to 60,000 s	1,250 s
Dyn.s: Cold load PU				
_:33	Log.-inv.-T #:Effect. b. cold-load pickup		• no • yes	no
_:40	Log. inv. T #:Stage blocked		• no • yes	no