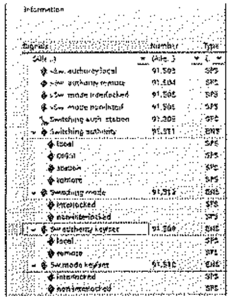


Figure 6-28 Display of Switching Authority and Switching Mode in Information Routing (in Function Block, General)

Sw. authority keyset and Sw.mode keyset indicate the current state of the key switch or parameter for switching authority or switching mode and provide this information for further processing in the CFC. In the CFC, for example, it is possible to set up an automatic routine to ensure that the switching authority is automatically set to Local when the key switch is set to non-interlocked.

The following table shows the dependency of the switching mode on the key-switch position and the switching authority. In the case of switching commands from Remote, the information on whether a locked or non-interlocked switching should take place is also sent. For this reason, the position of the key switch is irrelevant for the switching mode in these cases. The information in the table assumes that, in the case of remote switching commands or those from the station, the switching mode is interlocked in each case.

Table 6-18 Dependency of the Switching Mode on the Key Switch Position and Switching Authority

Key switch for switching mode	Switching Authority		
	Local	Remote	Station
Interlocked	Interlocked	Interlocked	Interlocked
Non-interlocked	Non-interlocked	Interlocked	Interlocked

The signals shown in Figure 6-28 in DIGSI 5 information routing have the following relationship:

- In terms of switching authority and switching mode, the respective key switch position serves as the input signal and the input signals in the matrix.
- The state of the switching authority and switching mode is indicated by corresponding output signals.
- The Switching authority and Switching mode functions link the input signals and in this way establish the output signals (see Figure 6-29 and Figure 6-30).

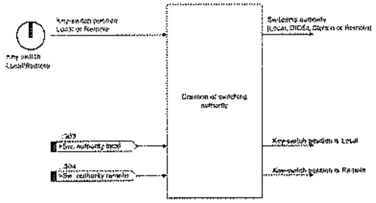


Figure 6-29 Establishing Switching Authority

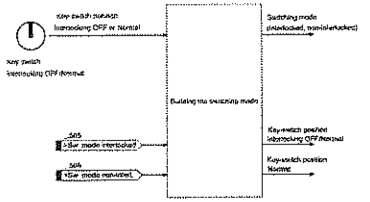


Figure 6-30 Establishing Switching Mode

In the case of both functions, the input signals override the state of the key switch. This allows external inputs to also set the switching authority or switching mode, if desired (for instance, by querying an external key switch).

The following additional settings are available for the switching authority:

- Activation of Switching Authority Station (defined in IEC 61850 Edition 2):
  If you would like to use this switching authority, set the check mark General/Control.
- Multiple Switching Authority Levels:
  This option permits switching commands from several command sources to the device if the switching authority Remote is selected. Subsequently, a distinction between these command sources can also be made. You can find more details in the following table. Activate this option by setting the check mark General/Control.
- Specific sw. authorities:
  You can enable additional options for the switching authority check. You can find more information about these options in chapter Specific Switching Authority, Page 298. By default, these are not used.

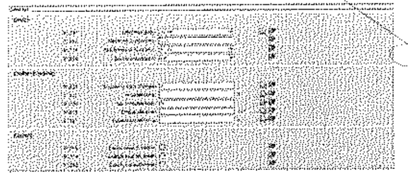


Figure 6-31 How to Activate the Station Switching Authority and to Enable Several Switching-Authority Levels

Table 6-19 Effect on Switching Authority when Several Switching-Authority Levels Are Enabled with/without Activation of the Station Switching Authority

Release Several Switching Authority Levels	Switching Authority in the Device	Status of DIGSI in the Device	Station Switching Authority Activated	State of the Station Switching Authority	Resulting Switching Authority
No	Local	-			Local
	Remote	Signed on	-		DIGSI
		Not signed on	No	-	Station and Remote
			Yes	Set	Station
				Not set	Remote
Yes	Local	-	-	-	Local
	Remote	Signed on	-	-	DIGSI
		Not signed on	No	-	Local and station and remote
			Yes	Set	Local and station
				Not set	Local and station and remote

The following table shows the result of the switching-authority check, based on the set switching authority and the cause of the command. This overview represents a simplified normal case (no multiple command sources when using Station and Remote).

Table 6-20 Result of a Switching Authority Check

Cause Source	Switching Authority			
	Local	DIGSI	Station	Remote
Local	Release	Blocked	Blocked	Blocked
Station	Blocked	Blocked	Release	Blocked
Remote	Blocked	Blocked	Blocked	Release
Local automatic operation	Release	Release	Release	Release
Station automatic operation	Blocked	Blocked	Release	Blocked
Remote automatic operation	Blocked	Blocked	Blocked	Release
DIGSI	Blocked	Release	Blocked	Blocked

Specific Switching Authority

Special switching authorities can be configured as extensions of the switching-authority check. This makes it possible to differentiate the Remote command sources at the bay level. Switching authorities can be issued to or revoked from different control centers that can, for example, belong to different companies. Thus, precisely one of these command sources can switch at a certain time. This function is based on extending the switching-authority check by verifying the identifier of the command source (Field Originator/orIdent of switching command). In order to turn on the function, go to General/Control and set the check mark for the parameter Specific sw. authorities. More settings for the configuration of the identifiers and the behavior of the function as well as additional signals appear (see Figure 6-32). In order to permit an additional command source to switch, you must activate the specific switching authority. In order to do this, set the controllable Enable sw. auth. 1 to Enable sw. auth. 5.

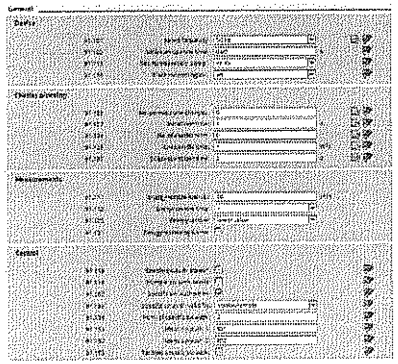


Figure 6-32 Activating Additional Options of the Switching Authority

The additional parameters allow you to set the following options:

- Specific sw.auth. valid for (for station/remote, only remote or only station):
  With this parameter, you determine for which command source the extended switching authority check is used.

Table 6-21 Result Derived from the Combination of the Parameter Value Specific sw.auth. valid for and the Level of the Command Source (Field Originator/orCat of the Switching Command)

Command Source	Specific sw.auth. valid for		
	station	station/remote	remote
Local, local automatic	No check	No check	No check
Station, station automatic	Check	Check	No check
Remote, remote automatic	No check	Check	Check
DIGSI	No check	No check	No check

- Num. of specific sw.auth.:
  With this parameter, you determine how many specific switching authorities are available. This determines the number of parameters Identifier switching authority as well as the controllable Active. Sw. auth.
- Identifier switching authority 1 to Identifier switching authority 5:
  The number of names that appear corresponds to the number set in the previous parameter. You can select the names as you wish; 1 to 64 characters are allowed. The command check verifies whether these titles correspond with those sent by the command source. This applies to the switching commands as well as to the activation of a specific switching authority. The requirement for this is the system interface IEC 61850. The field Originator/orIdent is used.
- Multiple specific sw.auth. ensures the simultaneous validity of the various command sources. The following table shows how to determine the resulting specific switching authority when activating the command sources of Remote or Station. If this parameter is activated, all parameterized command sources get permissible automatically (see last row in the table) and they cannot be deactivated via the controllable Enable sw. auth. 1 to Enable sw. auth. 5. Otherwise, the enabled command source with the lowest number has always the highest priority and prevails against the other numbers.

Table 6-22 Determining Switching Authority if Multiple Command Sources Are Available

Multiple specific sw.auth.	Enable sw. auth. 1	Enable sw. auth. 2	Enable sw. auth. 3	Enable sw. auth. 4	Enable sw. auth. 5	Resulting Specific Switching Authority
No	on	*	*	*	*	Switch. auth. 1
No	off	on	*	*	*	Switch. auth. 2
No	off	off	on	*	*	Switch. auth. 3
No	off	off	off	on	*	Switch. auth. 4
No	off	off	off	off	on	Switch. auth. 5
No	off	off	off	off	off	None
Yes	on	on	on	on	on	All

The * symbol in the previous table refers to any value.

266

Switching auth. station	91.308	SPC
Enable sw. auth. 1	91.324	SPC
off		SPS
on		SPS
Enable sw. auth. 2	91.326	SPC
off		SPS
on		SPS
Switching authority	91.311	ENS
local		SPS
DIGSI		SPS
station		SPS
remote		SPS
Switching mode	91.312	ENS
interlocked		SPS
non-interlocked		SPS
Sw.authority key/set	91.309	ENS
local		SPS
remote		SPS
Sw mode key/set	91.310	ENS
interlocked		SPS
non-interlocked		SPS

Figure 6-33 Display of Switching Authority and Switching Mode in the Information Routing (in Function Block General), Example of 2 Activated Remote Switching Authorities

Individual Switching Authority and Switching Mode for the Switching Devices

In a standard case, the functionalities switching authority, switching mode, and specific switching authority as described in the previous sections, are applicable to the entire bay unit and, therefore, are valid for all switching devices that are controlled by this bay unit. In addition, you can configure an individual switching authority and specific switching authority as well as individual switching modes for single switching devices. Therefore, individual switching devices can accept various switching authorities and switching modes simultaneously.

This is offered for the following function groups and function blocks:

- Circuit-breaker function group
- Disconnector function group
- Transformer tap changer function group
- Switching sequence function block

This allows to select individual settings for each switching device. This is useful if, for example, switching devices of different utilities are managed within a single bay.

In order to activate this option, go to the function block Control of a switching device and set the parameter Check: switching authority to advanced. An additional table containing initially 2 parameters is displayed.

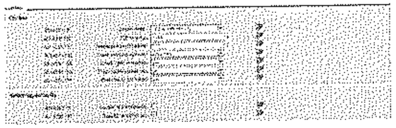


Figure 6-34 Additional Parameters for Switching Authorities in the Parameters of a Switching Device

When activating the parameter Swi. dev. related sw.auth., an individual switching authority as well as an individual switching mode for this switching device are configured. Additional signals are displayed in the Control function block of the corresponding switching device.

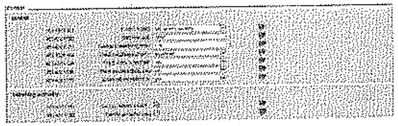


Figure 6-35 Expanded Parameters for the Switching Authority at the Switching Device

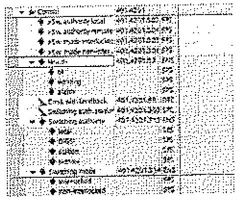


Figure 6-36 Individually Modifiable Switching Authority and Switching Mode for Switching Devices

The new input signals that are displayed allow you to set the individual switching authority and switching mode for the switching devices. For this switching device, these inputs overwrite the central switching

authority and the switching mode. The outputs Switching authority and Switching mode indicate the states only for this switching device.

When activating Specific sw. authorities, an individual specific switching authority for this switching device is configured. Additional parameters are displayed.

Figure 6-37 Parameters of the FB Control with all Additional Options

The functionality of the specific switching authority for the individual switching device and the significance of the additional parameters is identical to the operating mode of the central specific switching authority. Additional signals are displayed in the Control function block.

Control	202.4201	
Health	202.4201.53	ENS
Cmd. with feedback	202.4201.58	DPC
Switching auth. stati...	202.4201.302	SPC
Enable sw. auth. 1	202.4201.308	SPC
off		SPS
on		SPS
Enable sw. auth. 2	202.4201.309	SPC
off		SPS
on		SPS

Figure 6-38 Specific Switching Authority, Modifiable for each Switching Device

Switching Direction (Set = Actual)

With this check, you avoid switching a switching device into a state that has already been achieved. For instance, before a trip command is issued to a circuit breaker, its current position is determined. If this circuit breaker is already in the Off position, no command is issued. This is logged accordingly.

Switchgear Interlocking Protection

Switchgear interlocking protection means avoiding maloperation by checking the bay and substation interlocking and thus preventing equipment damage and personal injury. The interlocking conditions are always system specific and for this reason are stored as CFC charts in the devices.

SIPROTEC 5 devices recognize 2 different types of interlocking conditions:

- Normal interlocking conditions:
  These can be revoked by changing the switching mode to non-interlocked.

- Non-revocable (fixed) interlocking conditions:
  These are still checked even if the switching mode is set to non-interlocked.
  Application: Replacing mechanical interlocking, for example, that prevent actuation of a medium-voltage switch.

Each of the two categories has 2 release signals (for the On and Off switching directions) that represent the result of the interlocking plan, so that interlocking is in effect during the command check (see the figure below). The default setting for all release signals is TRUE so that no switchgear interlocking checks take place if no CFC charts have been prepared.

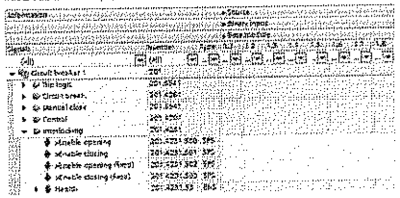


Figure 6-39 Interlocking Signals in Function Block Interlocking

EXAMPLE

For interlocking

For the making direction of the circuit breaker QA in bay E01 (see the figure below), it is necessary to check whether the disconnectors QB1, QB2, and QB9 are in the defined position, that is, either On or Off. Opening the circuit breaker QA should be possible at any time.

The interlocking equations are: QA_On = ((QB1 = On) or (QB1 = Off)) and ((QB2 = On) or (QB2 = Off)) and ((QB9 = On) or (QB9 = Off)). There is no condition for opening.

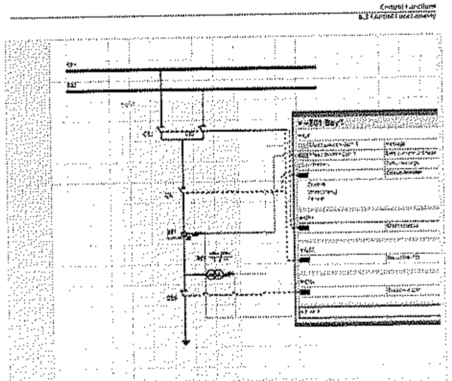


Figure 6-40 Feeder Bay for a Double Busbar System

The CFC chart that is required to implement the interlocking equation is shown in the next figure.

Figure 6-41 Interlocking Chart for Bay Interlocking

Since the Disconnector function block provides the defined position Only OFF, the exclusive OR gate XOR is not necessary for interlocking. A simple OR suffices.

As can be seen in the CFC chart, the result of the check is connected to the >Enable on signal in the Interlocking function block in the Circuit breaker QA function group (see Figure 6-39).

EXAMPLE

For system interlocking

This example considers the feeder = E01 from the previous example (bay interlocking) and additionally the coupler bay = E02 (see the figure below).

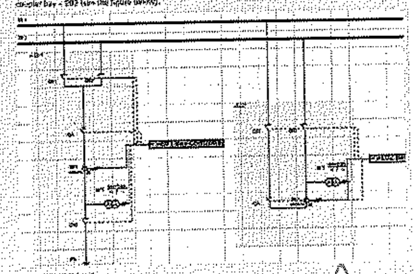


Figure 6-42 System with Feeder and Coupler Bays

The circuit breaker QA in coupler bay = E02 will be considered next. As the multibay interlocking condition, you must provide the bus-coupler command block at the end.

If the 2 busbars in bay = E01 are connected, that is, if the 2 disconnectors QB1 and QB2 in bay = E01 are closed, the circuit breaker QA in bay = E02 is not allowed to be switched off. Accordingly, bay = E01 in the CFC of the device generates the indication Bus coupler closed from the positions of the switches QB1 and QB2 and, using IEC 61850-GOOSE, transmits it to bay = E02 in the device. You must then view the following interlocking condition in bay = E02:

QA_Off = NOT (= E01 bus coupler closed)

In the CFC chart for the coupling device = E02, you must create the following CFC chart (see also figure below).

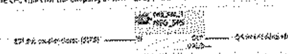


Figure 6-43 Interlocking Chart for Substation Interlocking

267

1-Out-of-n Check (Double-Activation Blocking)

The double-activation blocking prevents 2 commands from being executed in the device simultaneously. You can set the device-internal check for each switching device as a parameter in the Control function block. The default setting is Yes, that is, double-activation blocking is active (see the figure below).

Figure 6-44 Activating the Double-Activation Blocking

With SIPROTEC 5, it is also possible to achieve multibay double-activation blocking.

In this case, send the signal not selected to other devices for analysis using IEC 61850-GOOSE. This signal is available under Position in every Circuit breaker or Disconnector function block of the switching device function groups (see figure below).

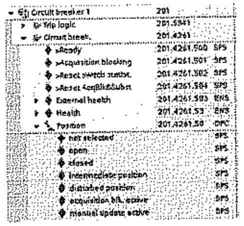


Figure 6-45 Signal not selected in the Circuit-Breaker Function Block

The signal is then queried in the CFC interlocking conditions for the associated switching devices and is used to generate the release signal (for example, >Release on).

External 1-of-N Check (Cross-Bay Double-Activation Blocking)

The function block Ext. 1-of-N check offers another option to implement a cross-bay 1-out-of-n check. You can select this function block in the FG Circuit breaker – Control in the DIGSI library. This function makes it possible to interlock other switching devices across all bays before the allocation of the switching device takes place in its own assigned bay or before the switching operation can be executed.

You can use the function block Ext. 1-of-N check in the Circuit breaker and Disconnector function groups. In order to use the function, a control model with feedback monitoring must be configured in the circuit breaker control.

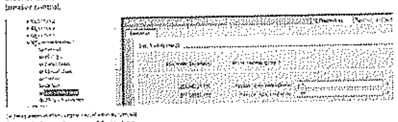


Figure 6-46 Command Execution

If the external 1-of-N check is instantiated, the output Release request prompts a central bay controller before executing a switching command. This bay controller must permit the switching operation (see the following figure). If the allocated switching devices were locked in another bay, the release is issued. Only when the release was issued via the input >Release active the allocations (Control model: SBO w. enh. security) or the switching command (Control model: direct w. enh. security) are executed and confirmed. The central bay controller is parameterized to reject a 2nd switching request.

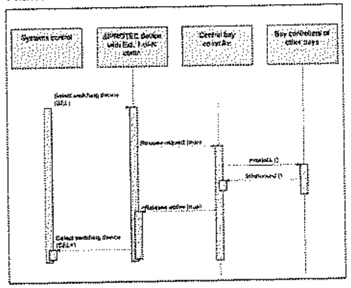


Figure 6-47 Setting the Blocking

Once the switch position has been reached, interlocking of the switching devices is canceled via the output Release request. The switching command is completed and acknowledged with CMT (see the following figure) only when interlocking termination has been acknowledged positively via the input >Release active.

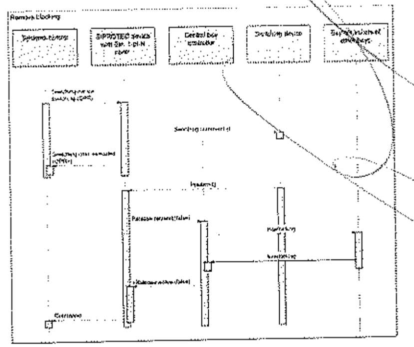


Figure 6-48 Terminating the Blocking

User I/O Objects of the External 1-of-N Check Function Block

Name	I/O	Description	Range
Release request	O	This output remains active from the time of the switching prompt until the new position is reached.	true/false
>Release active	I	If this input is set, the switching device is released for switching operation. As long as this input is not set, this switching device is blocked for additional switching operations.	true/false

Blocking by Protection Function

- Default setting (_:2307) Check blk. by protection = yes

In devices with protection and control functions, Siemens recommends that no switching commands can be issued while protection functions have picked up.

The default setting for blocking by the protection function is therefore yes. If necessary, you can disable this blocking. You can find the settings on the same page as the double-activation blocking (see Figure 6-34).

NOTE

Remember, for instance, that pickup of the thermal overload protection can create a fault as well and thus prevent switching commands.

NOTE

Note that the command check Blocking by protection function is only available for controlling circuit breakers, because in this case a unique relationship with protection functions has been configured. In disconnectors, this relationship is not always unique, precisely with regard to the 1 1/2 circuit-breaker layout, and it must be mapped for each system using CFC charts.

To carry out the command check Blocking by protection function for disconnectors, use the following indications (if present) in your interlocking conditions:

- Group indication: Pickup (function group VI 3-phase, VI 1-phase or V 3-phase)
- Circuit-breaker failure protection: Pickup (Circuit-breaker failure protection)

6.3.2 Command Logging

All commands in the sequence are logged. The command log contains:

- Date and time
- Name of the switching device (or function group)
- Reason for the transmission (SEL = Selecting, OPR = Operate, CMT = Command execution end, SPN = Spontaneous)
- Status or switching direction

EXAMPLE

The following example illustrates control of a circuit breaker QA1 for various cases:

- Successful command output
- Interrupted command
- Command interrupted by switchgear interlocking
- Command ended due to missing feedback
- Spontaneous change of switch position without command output

The following figures indicate command logging for various scenarios of the standard control model SBO with feedback monitoring.

Figure 6-49 Positive Case (Display 1)

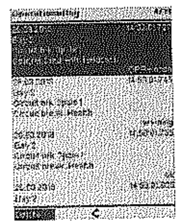


Figure 6-50 Positive Case (Display 2)

Figure 6-51 Positive Case (Display 3)

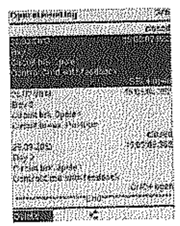


Figure 6-52 Positive Case with Command Cancellation

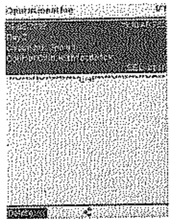


Figure 6-53 Negative Case (Blocked by Switchgear Interlocking)

Figure 6-54 Negative Case (Expiration of Feedback Supervision Time) (Display 1)

Figure 6-55 Negative Case (Expiration of Feedback Supervision Time) (Display 2)

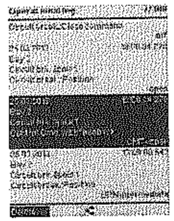


Figure 6-56 Negative Case (Expiration of Feedback Supervision Time) (Display 3)

Figure 6-57 Spontaneous Status Change

Depending on the transmission reason, the desired control value or the actual state value of the controllable and the switching device can be contained in the log.
The following table shows the relationship.

Table 6-23 Relationship between the Reason for Transmission and the Value Logged

Reason for Transmission	Value
Selected (SEL)	Desired value
Operate (OPR)	Desired value
Command cancellation (CNC)	Desired value
Command execution and termination (CMT)	Actual value
Spontaneous change (SPN)	Actual value

6.3.3 Application Notes and Setting Notes for the External 1-of-n Check Function Block

Parameter: Feedba. mon. time release

- Default setting (_:101) Feedba. mon. time release = 5.00 s

With the parameter Feedba. mon. time release, you specify the time within which the release request must be confirmed via the input >Release active.

Parameter: Feedba. mon. time reset

- Default setting (_:102) Feedba. mon. time reset = 5.00 s

With the parameter Feedba. mon. time reset, you specify the time within which the withdrawal of the release request must be confirmed via the input >Release active.

6.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:104	Control:Check switching authority		• no • yes	yes
_:105	Control:Check if pos. is reached		• no • yes	yes
_:106	Control:Check double activat. blk.		• no • yes	yes
_:107	Control:Check blk. by protection		• no • yes	yes

6.3.5 Information List

No.	Information	Data Class (Type)	Type
Control			
_:53	Control:Health	ENS	O
_:58	Control:Cmd. with feedback	DPC	C

6.4 Synchronization Function

6.4.1 Overview of Functions

The Synchronization function (ANSI 25) checks whether the activation is permissible without a risk to the stability of the system when interconnecting 2 parts of an electrical power system. Typical applications are the synchronization of a line and a busbar or the synchronization of 2 busbars via a cross-coupling. A power transformer between the 2 measuring points can also be taken into consideration.
The following operating modes are covered:

- Synchrocheck
- Switching synchronous power systems
- Switching asynchronous power systems
- Switching to dead line/dead busbar

6.4.2 Structure of the Function

The Synchronization function is used in the Circuit-breaker function group.
2 different types of stage can be used within the function:

- Synchrocheck stage
- Synchronous/asynchronous stage

Each of the stage types is preconfigured at the factory. You can operate maximum 2 stages of the synchrocheck stage type and maximum 6 stages of the synchronous/asynchronous type in parallel. In addition, the Expanded dCtrl options stage type is available in the function library. It is not preconfigured.
As soon as the device is functional, the function measuring points are calculated and displayed.

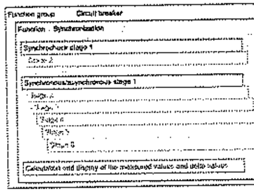


Figure 6-58 Structure/Embedding of the Function

6.4.3 Connection and Definition

Connection

You can find examples for the synchronization of line and busbar in the following 2 figures. Figure 6-61 shows an example for the synchronization of 2 busbars via bus coupler.

The synchronization function uses 2 voltages to check the connecting conditions: a voltage of the reference side 1 (V1) as well as a voltage to be used as a reference on side 2 (V2). The reference voltage of side 1 is designated in the synchronization function as V1[1]. This is always the voltage of the measuring point that is connected to the **Sync. voltage 1** interface of the Circuit-breaker function group. The voltage to be set as reference is designated with V2[1]. This is always the voltage of the measuring point that is connected to the **Sync. voltage 2** interface of the Circuit-breaker function group. The assignment of the measuring points to the interfaces of the circuit-breaker function group can be configured, see chapter 2.1 Function Embedding in the Device.
The selection of the voltages used for the synchronization depends on the device connection to the primary system:

- Connection of the primary system via 4 voltage inputs and hence use of a 1-phase and a 3-phase measuring point (Figure 6-59 and Figure 6-61):
  The voltage connected to the 1-phase measuring point is definitive here. If, for example, this is the phase-to-ground voltage V_A, the voltage V_A is also used by the other side of the 3-phase measuring point.
- Connection of the primary system via 6 voltage inputs and hence use of two 3-phase measuring points (Figure 6-60):
  The phase-to-phase voltage V_{AB} of both sides is always used for the test.

You can connect both the phase-to-ground voltages and the phase-to-phase voltages to the device. The possible interface connections are listed in the Appendix.

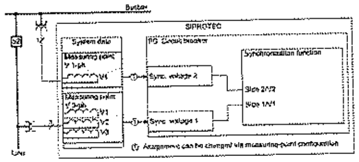


Figure 6-59 Synchronization of Line and Busbar, Connection via 4 Voltage Inputs

[1] Do not confuse the designation V1 and V2 with the terminals of the voltage inputs V1 to V4 (Figure 6-59) and V1 to V4

269

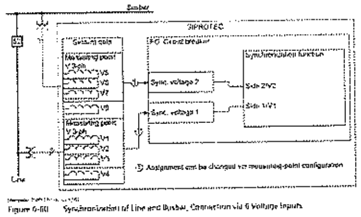


Figure 6-60 Synchronization of Line and Busbar, Connection via 6 Voltage Inputs

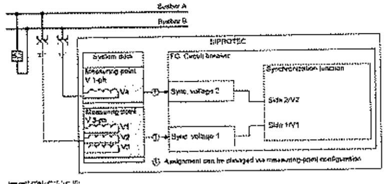


Figure 6-61 Synchronization of 2 Busbars via Cross Coupling, Connection via 4 Voltage Inputs

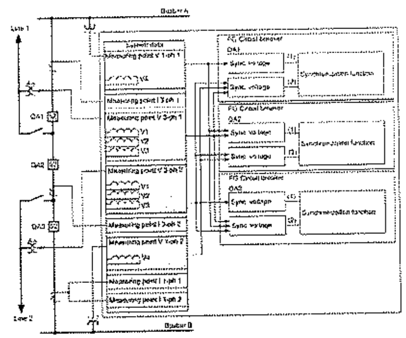


Figure 6-62 Synchronization with dynamic measuring point toggling at 1.5 circuit breaker stage

Definition of the Variables

The definition of the variables is important for understanding the following implementation. The reference side 1 indicates the function with 1. This yields the reference values voltageV1, frequencyf1, and phase angle α1. The side to be synchronized indicates the function with 2. The electrical variables of side 2 are then the voltageV2, frequencyf2, and phase angle α2.

When forming the differential variables, the function is oriented to the definition of the absolute measuring error (Δ x = measured value – real value). The reference value and hence the real value is side 1. This results in the following calculation specifications:

Differential voltage dV = V2 – V1

A positive sign means that the voltage V2 is greater than the voltage V1. In other cases, the sign is negative.

Differential frequency df = f2 – f1

A positive result means that according to the example from Figure 6-59 the busbar frequency is greater than the line frequency.

Phase angle difference dα = α2 – α1

The representation is limited to ±180°. A positive result means that α2 leads by a maximum of 180°. In the case of a negative value, α2 lags by a maximum of 180°. Figure 6-63 shows the circumstances. The phase angle α1 was added to the zero axis as reference system.

If asynchronous systems are present and the frequency f2 is greater than f1, the angle dα then changes from the negative value to 0 and then to the positive value. As shown in Figure 6-63, the direction of rotation is counterclockwise (mathematically positive). At f2 < f1, the direction of rotation is clockwise.

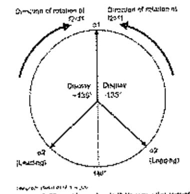


Figure 6-63 Phase-Angle Difference Representation dα

Only positive values are permissible for the setting parameters. Inequalities are used to characterize the setting parameters uniquely. The representation is explained with the example of differential voltage. 2 setting values are necessary to allow unbalanced settings.

The inequality V2 > V1 yields a positive value for dV. The associated parameter is Max. voltage diff. V2>V1. For the 2nd setting parameter Max. voltage diff. V2<V1, the inequality V2 < V1 applies. It corresponds to a negative dV.

The procedure is the same for the differential frequency and differential phase angle.

6.4.4 General Functionality

Overview of a Synchronization Stage (Sync Stage)

A synchronization stage can be integrated in the following blocks (see Figure 6-64):

- Stage control with mode, state control, standby and blocking (description in this chapter)
- Supervision (description in this chapter)
- Functional sequence for issuing the closing release (see chapter 6.4.6 Sequence of Functions)

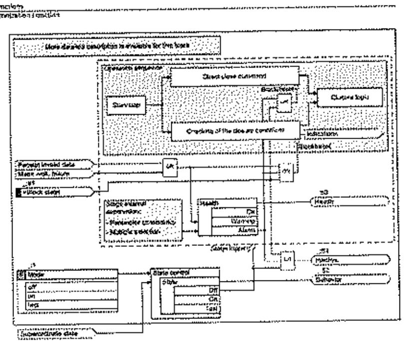


Figure 6-64 Overview of the Stage Logic

Stage Control

The normal stage control is used for a synchronization stage (see Figure 6-64).

Note the following special features:

- As soon as there is a synchronization function available in the device, the measured values are calculated and displayed. One stage must be activated for calculating all Delta settings. It is not necessary to start the stage for this purpose.
- If all synchronization stages are deactivated within the function, closure via the control will no longer be possible, as none of the stages can generate an closing release. If the synchronization function is deleted, the circuit breaker is no longer regarded as subject to compulsory synchronization. In this case, it is possible to activate via the control without synchronization.
- If more than one synchronization stage is switched on, then the >Selection signal must be active for exactly one stage, so that it can be activated via the controls.

You can block the entire synchronization stage via the binary signal >Block stage. A started process is completed and the entire stage reset after blocking. The stage must be restarted to initiate a new switching procedure. The blocking only affects the test process for the closing conditions. The measured values are still calculated and displayed.

Operating Range

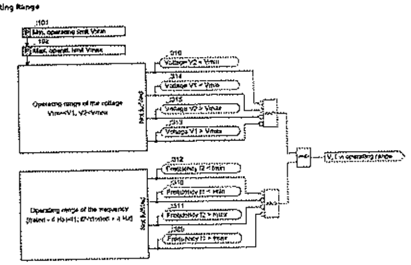


Figure 6-65 Logic of the Operating Ranges

The operating range of the synchronization function is defined by the configurable voltage limits Min. operating limit Vmin and Max. operat. limit Vmax as well as by the specified frequency band f_{rated} ±4 Hz.

If one or both voltages are outside the permitted operating range when the measurement is started or a voltage leaves the range, this is displayed via corresponding indications Frequency f1 > fmax, Frequency f1 < fmin, Voltage V1 > Vmax, Voltage V1 < Vmin etc. The closing conditions are then not checked.

Supervision

The supervisions listed below are executed in a function-specific manner. If one of the monitors picks up, the health goes to Alarm. The stage is indicated as Inactive. A closing release or direct close command is not possible in this case.

- For consistency of settings of specific parameters
  Delta-to threshold-value settings are checked after a parameter change. If there is an inconsistency, the error message Setting error is set.
- For multiple selection of the stage at the start time of the synchronization
  If there is a simultaneous selection of multiple closed synchronization stages at the start time, the error message Multiple selection is set.

Measuring-Voltage Failure

If a voltage transformer fault (measuring-voltage failure) is recorded via the binary input signal >Open of one of the voltage measuring points, then the closing conditions of the synchronization stage are no longer tested. In other words, a release of the closing based on the measurement is no longer possible. The readiness of the stage turns to Warning. Direct close command is still possible.

The device-internal supervision function measuring-voltage failure detection (Fuse Failure Monitor) does not have any effect on the synchronization stage.

Function Measured Values

The function measured values for the Synchronization function are displayed in their own primary, secondary and percentage measured-value windows. Voltage measurements are always displayed as ph-ph voltages, even if the associated measuring point records phase-to-ground voltages. The function measured values are determined and displayed as soon as the device is functional. The difference values are calculated as soon as the stage is activated.

Table 6-24 Protection-Specific Values of the Synchronization

Values		Primary	Secondary	% Referenced to
V_1	Reference voltage V_1	kV	V	Rated operating voltage of the primary values
V_2	Voltage to be synchronized V_2	kV	V	Rated operating voltage of the primary values
f_1	Frequency of the voltage V_1	Hz	Hz	Rated frequency
f_2	Frequency of the voltage V_2	Hz	Hz	Rated frequency
dV	Voltage difference V_2-V_1	kV	V	–
df	Frequency difference f_2-f_1	Hz	Hz	–
dα	Angle difference $α_2$-$α_1$	°	°	–

Multiple Synchronization Points

The synchronization function can only be used within a Circuit-breaker function group. It always operates on the circuit breaker that is linked to the Circuit-breaker function group. The reference to the circuit breaker is therefore unique. If you wish to switch several circuit breakers (synchronization points) with the device, you must create several Circuit-breaker function groups.

Different Synchronization Conditions per Synchronization Point

Within the synchronization function, you can operate maximum 2 stages of the stage type Synchrocheck and maximum 6 stages of the type Synchronous/asynchronous in parallel. All setting parameters for a synchronization point are included in each synchronization stage.

If you have to synchronize with different synchronization conditions (parameter settings), several synchronization stages are used for a synchronization point/circuit breaker. In this case, you must define which of the synchronization stages is currently active via the binary signal >Selection (synchronization stage x). The closing conditions are checked if the respective stage is activated via the >Selection binary signal and the stage is activated.

The fault indication Multiple selection is issued upon simultaneous selection of different synchronization stages. If several synchronization stages are activated and the input signal >Selection (synchronization stage x) is missing at the starting time, a valid selection is awaited during the supervision time Max. durat. sync. process. If this does not come, the process is terminated.

Different Voltage-Transformer Ratios of Both Parts of the Electrical Power System

The settings of the rated parameters of the transformer for the measuring points automatically takes the different voltage-transformer transformation ratios of both parts of the electrical power system into account. The Voltage adjustment parameter is not needed for this purpose.

Synchronization via a Transformer

There are systems in which a power transformer is located between the voltage measuring points of the circuit breaker to be synchronized. The device automatically considers the different voltage stages by setting the transformer ratios (within the measuring points).

A phase displacement must be taken into account based on the transformer vector group, via the Angle adjust. (transform.) parameter.

270

The parameter is defined as (Vsec side2 / Vsec side1).

To calculate the Delta parameters, the voltage of side 2 is converted to the voltage of side 1 using to the settings of both parameters.

In the Application and Setting Notes, several examples are provided for using both parameters.

Different Connection Types on Both Sides

If both of the measuring points used by the synchronization functions record different voltages of the 3-phase system, the calculation of the phase displacement angle is automatically taken into consideration.

EXAMPLE:

The 1-phase measuring point connected with Sync voltage 1 records the phase-to-phase voltage V_{AB}. The 1-phase measuring point connected with Sync voltage 2 records V_A. In this case the phase angle between V_{AB} and V_A takes into consideration the delta available for during calculation.

This automation guarantees that several voltage sources can be switched between during running operation, each of which records different voltages.

6.4.5 Dynamic Measuring-Point Switching

Dynamic measuring-point switching provides the capability to connect the voltages used in the Synchrocheck function to various measuring points. In this way, for example, it is possible to use the correct voltage on the basis of the switch position on the switching devices. If more than 1 measuring point is connected to V sync1 or V sync2, you must create the V sync. select. function block in the Circuit breakers function group.

Selection of the existing voltage measuring points (V sync1 and V sync2) for the Circuit breakers function group is controlled via Continuous Function Chart.

Example

Figure 6-66 shows an example of a Synchrocheck in a breaker-and-a-half arrangement. If circuit breaker QA2 is to be closed, the reference voltages must be selected from several possible measuring points. This selection of measuring points is dependent on the switch positions of all circuit breakers and disconnectors.

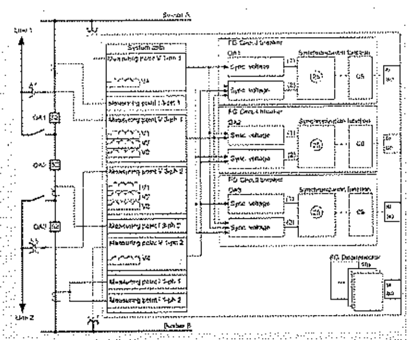


Figure 6-66 Synchronization in a Breaker-and-a-Half Arrangement

Each synchronization function requires 2 comparison voltages. For the circuit breaker QA2 located in the middle, there are 2 options for each side (V_{sync1} and V_{sync2}). The selection of synchronization voltages for each side depends on the position of the circuit breaker and the disconnectors.

For circuit breakers QA1 and QA3, the feeder voltage (V_{sync1}) is available for one side, but 3 voltages (V_{sync2}) are available for the other side.

Connecting Measuring Points to Circuit-Breaker Function Group

The following figure shows the connection of the Circuit breaker function group with several measuring points in DIGSI. The ID of each measuring point appears in parentheses after the name.

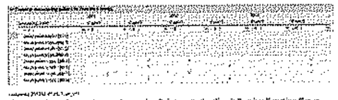


Figure 6-67 Connecting the Measuring Points with the Circuit-Breaker Function Group

There are consistency checks that validate the connections of voltage measuring points to the function group:

- The connection type must be identical for all measuring points connected to the same interface.
- It is not permitted to route a measuring point to the function group using the option VII.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to 1 voltage interface, a function block must be expanded to enable selection of the synchronization voltage.

CFC Control

The voltages are selected by CFC logic on the basis of the measuring point IDs. If more than one measuring point is connected to interfaces V_{sync1} or V_{sync2} of the Circuit-breaker function group, the V sync. select. function block has to be removed from the library in the Circuit-breaker function group. A CFC logic (see following example) has to define IDs for the V sync1 or V sync2 inputs of this function block in order to ensure the correct measuring point connection for the Synchrocheck function.

Figure 6-68 CFC Logic: Voltage Selection Using Measuring Point ID

If no measuring point can be selected because of the switch or disconnector positions, the ID0 is used. If ID0 is selected, the indication (_:2311:304) Blocked no V selected is set. The synchrocheck is blocked. If you have activated the parameter (_:5071:108) Direct close command, unsynchronized switching is still possible.

6.4.6 Sequence of Functions

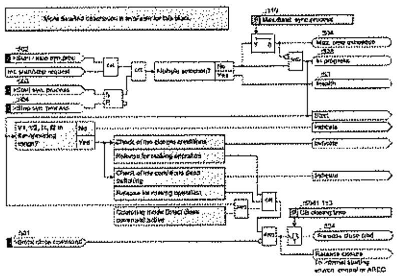


Figure 6-69 Sequence of Functions

Start

The synchronization stage must be started to check the closing conditions. The synchronization stage can be started device-internally by the controller or externally via binary input signals (see section 6.4.12 Interaction with Control and External Triggering).

At the start, the system checks whether there is a multiple selection by the synchronization stage (see section Monitoring in chapter 6.4.4 General Functionality). If this is the case, the process is terminated. After a successful start, the indication In progress is cleared and the supervision time for the maximum duration of the synchronization process (parameter Max. durat. sync. process) is started. The system also checks whether the voltages and frequencies are in the operating range (see section 6.4.4 General Functionality). If this is not the case, the closing conditions are not checked.

Checking the Closing Conditions, Closure

After starting, the parameterized closing conditions are checked depending on the operating mode selected (see Chapter 6.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type to 6.4.11 Direct Close Command). Every condition fulfilled is explicitly indicated here. Conditions not fulfilled are also indicated. If all conditions are fulfilled, the synchronization stage sets the indication All sync. condit. OK. This indication is active until all conditions are fulfilled. The further behavior for issuing the release for closing depends on the type of the stage (see Chapters 6.4.7 Closing Conditions for the Synchrocheck Stage Type and 6.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type). The release is signaled via the Release close cmd. indication. This indication is active for 100 ms. With an external start, the controller executes the actual closure, depending on the starting source.

Switching to Dead Line/Busbar

If operating modes for switching to dead parts of an electrical power system are configured, the associated conditions are also checked after the start (see chapter 6.4.10 Closing at De-Energized Line/Busbar). The fulfilled conditions are signaled. An adjustable supervision time is started after the closure conditions are fulfilled (parameter CB. exten. time). If the conditions remain valid until expiry of the time, the function gives the release for closure after expiry of the time.

Direct Closing Command

If the Direct close command operation is active, the function instantaneously initiates the release for closure after the successful start (see chapter 6.4.11 Direct Close Command). A combination of direct close command with other release conditions is not advisable, as these conditions are bypassed by the direct close command.

End of the Process

If the function is started via the device-internal controller, these functions also terminate the synchronization process upon closure. The process is terminated via the corresponding binary signals in case of external starting.

If the supervision time (Max. durat. sync. process parameter) has expired, the process is also completed and the indication Max. time exceeded is issued. A renewed synchronization is only possible if the stage is restarted.

Blocking Closure

You can use the input signal >Block close command to block the release signal for the closure (signal Release close cmd.) as well as the closure itself. The measurement continues to operate during the blocking. If the blocking is revoked and the release conditions are still fulfilled, the release is given for closure.

6.4.7 Closing Conditions for the Synchrocheck Stage Type

Checking Closing Conditions

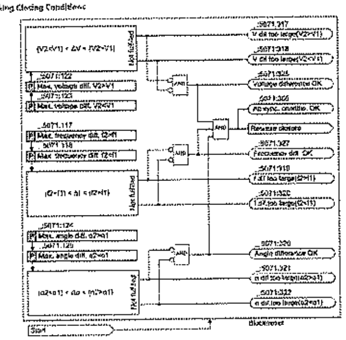


Figure 6-70 Closing Conditions for the Synchrocheck Function

With this operating mode, the values ΔV, Δf, and Δα are checked before connecting the 2 parts of the electrical power system. The indication All sync. condit. OK signals that the setting values (conditions) have been reached and that the release for closure has been given (see Checking the Closing Conditions, Closure in section 6.4.6 Sequence of Functions).

Every fulfilled condition is signaled individually via the indications Voltage difference OK, Frequency diff. OK, and Angle difference OK.

If a condition is not fulfilled, detailed information on why the condition is not fulfilled is provided via indications. If the differential voltage is outside the setting limits, for example, the indication V diff. too large(V2>V1) is issued. The indication indirectly contains information that the voltage V2 has to be increased for a successful synchronization.

With the Expanded delta-f options stage type configured and an activated (_:140) Inhib. df/dt for sync. op. parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter (_:141) Max. value df/dt for sync) is exceeded, the indication (_:329) df/dt too large is issued.

6.4.8 Closing Conditions for the Synchronous/Asynchronous Stage Type

A distinction according to synchronous and asynchronous systems can be made with this type of stage.

If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic for synchronous systems is equality of frequency ($\Delta f \approx 0$). If the frequency difference falls below the setting value of the f-threshold ASYN<->SYN parameter, synchronous systems are to be assumed. If the frequency difference exceeds the setting value of the f-threshold ASYN<->SYN parameter, asynchronous systems are to be assumed. This status occurs in galvanically isolated systems, for example.

Both states have their own operating mode with its own closing conditions. Both operating modes can be switched on and off separately (parameter Sync. operating mode and Async. operating mode). The following combinations result from this:

Sync. operating mode	Async. operating mode	Functionality
on	on	If the frequency difference is below the threshold value set f-threshold ASYN<->SYN, the operating mode synchronous is active. In other cases, the operating mode asynchronous is active.
off	on	Regardless of the frequency difference and the threshold value f-threshold ASYN<->SYN, the operating mode is exclusively active asynchronously.
on	off	If the frequency difference is below the threshold value set f-threshold ASYN<->SYN, the operating mode synchronous is active. In other cases, the stage is inactive, i.e. a switching release cannot be issued.
off	off	Both operating modes are deactivated. No activation release can be be given via these operating modes either.

Checking the Closing Conditions in Synchronous Systems

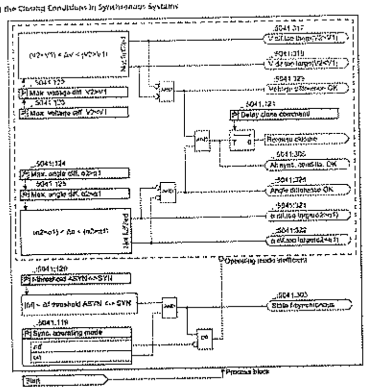


Figure 6-71 Closing Conditions when Switching Synchronous Systems

The frequency difference is very low in the synchronous system operating mode. It is below the threshold value f-threshold ASYN<->SYN. The status is signaled via the State f-synchronous indication.

The parameters ΔV and $\Delta \alpha$ are checked for issuing an activation release (see Figure 6-72). The indication All sync. conditions OK signals that both setting values (conditions) are reached. If the conditions remain fulfilled over the set time delay (parameter Delay close command), the release for closing is given (see also chapter 6.4.7 Closing Conditions for the Synchrocheck Stage Type).

Every condition fulfilled is signaled individually via the indications Voltage difference OK and Angle difference OK.

If a condition is not fulfilled, detailed information on why the condition is not fulfilled is provided via indications. If the differential voltage is outside the setting limits, for example, the indication V diff. too large(V2<V1) is issued. The indication indirectly contains information that the voltage V2 has to be increased for a successful synchronization.

With the Expanded delta-f options stage type configured and an activated (_:142) Limit dfdiff/dt for asyn. op parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter (_:143) Max. value dfdiff/dt asyn) is exceeded, the indication (_:379) d fdiff/dt too large is generated.

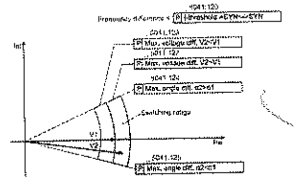


Figure 6-72 Connecting Under Synchronous System Conditions

Checking Closing Conditions in Asynchronous Systems

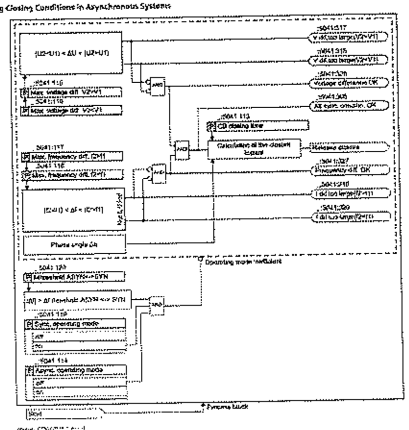


Figure 6-73 Closing Conditions when Switching Asynchronous Systems

In this operating mode, compliance with the voltage difference ΔV and frequency difference Δf conditions is checked. The function calculates the time point of the close command taking into account the angular difference $\Delta \alpha$ and the closing time of the circuit breaker. This is calculated so that the voltage phasors are equal at the moment of pole contact by the circuit breaker ($\Delta V \approx 0$, $\Delta \alpha = 0$).

Ranges in the Voltage-Frequency Diagram (V-f Diagram)

Figure 6-74 shows the setting parameters for synchronous and asynchronous conditions in the V-f diagram. The frequency range is very narrow owing to the functional principle in the case of synchronous systems.

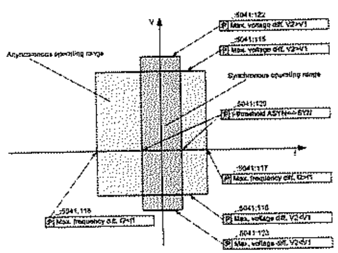


Figure 6-74 Operating Range Under Synchronous and Asynchronous Conditions for Voltage (V) and Frequency (f)

6.4.9 Expanded Checks (df/dt and Smoothing of Oscillations)

When configuring the Expanded delta-f options function block, you can expand the synchronization checks to include the following aspects:

- Limitation of the frequency change rate
  With this option, you can define additional upper limits for the rate of permissible frequency difference change. The release checks for both stage types take these additional upper limits into consideration. Both activation (parameters (_:140) Limit dfdiff/dt for sync. op and (_:142) Limit dfdiff/dt for asyn. op) and the upper limits (parameters (_:141) Max. value dfdiff/dt syn and (_:143) Max. value dfdiff/dt asyn) for the frequency change rate are adjustable selectively for synchronous and asynchronous conditions. Both stage types consider the frequency change rate when issuing the release for switching and indicate when the rate is exceeded.
  If you also activate the option to compensate for low-frequency oscillations (parameter (_:150) Suppr. frequ. oscillations), the frequency change rate is stabilized in the presence of such oscillations. Stabilization is in effect for asynchronous as well as synchronous operating modes.

- Compensation for low-frequency oscillations
  If you activate this option (parameter (_:150) Suppr. frequ. oscillations), low-frequency oscillations, for example, as a consequence of power swings in the range of 0.1 Hz to 1.6 Hz are detected and smoothed. This stabilizes the release checks in the presence of frequently changing violations of upper and lower limits for the specified frequency threshold values. The option affects the frequency check of the Synchrocheck stage types and the synchronous operating mode of the Synchronous/Asynchronous stage type. It does not affect the asynchronous operating mode.
  In the example of the following figure, the synchrocheck function would initiate energization, if the allowed frequency difference was set to 10 mHz without the parameter Suppr. frequ. oscillations as soon as the frequency f2 enters the 10 mHz band. If the parameter Suppr. frequ. oscillations is activated, energization is not initiated, since the average value of f2 is outside the band.

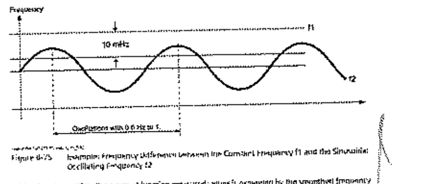


Figure 6-75 Example: Frequency Difference between the Constant Frequency f1 and the Sinusoidal Oscillating Frequency f2

With this option active, the range of function measured values is expanded by the smoothed frequency. Release of switching in synchronous networks occurs after one second at the earliest. This time is needed to smooth the frequency measured values.

The actual frequency can be larger or smaller than the smoothed value at any instant. The Max. diff. inst. threshold df parameter makes it possible to limit the increase in instantaneous frequency value in relation to the respective frequency threshold value.

6.4.10 Closing at De-Energized Line/Busbar

If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes.

If the measured voltage is less than the threshold V1, V2 without voltage, the zero potential of the part of the electrical power system is detected. In this case, all phases are compared to the parameter V1, V2 without voltage. The energized side must be in the defined operating range with respect to voltage and frequency (see chapter 6.4.4 General Functionality) and all phases must exceed the threshold V1, V2 with voltage.

The following additional closing conditions can be selected, which are then applied next to the closing conditions for the synchronism:

Settings	Description
Close cmd. at V1< & V2>	Closing release under the condition that the part V_1 of the power system is energized and the part of the electrical power system U_2 is de-energized.
Close cmd. at V1< & V2>	Closing release under the condition that the part V_1 of the power system is de-energized and the part of the electrical power system U_2 is energized.

Settings	Description
Close cmd. at V1< & V2<	Closing release provided the voltages V1 and V2 are de-energized.

Each of these conditions can be made effective individually via parameter or binary input. You can also set parameters for combinations, for example a release for closure, if Close cmd. at V1> & V2< or Close cmd. at V1< & V2> has been fulfilled.

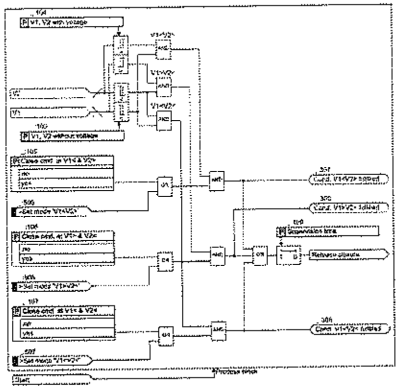


Figure 6-76 Release Conditions for Switching to De-Energized Line/Busbar

The indications Cond. V1<V2> fulfilled, Cond. V1>V2< fulfilled and Cond. V1<V2< fulfilled indicate that the relevant conditions are fulfilled.

You can use the Supervision time parameter to set a supervision time for which the closing conditions must at least be fulfilled with de-energized connection, before closing is allowed.

6.4.11 Direct Close Command

You can activate the operating mode Direct close command statically via the Direct close command parameter or dynamically with the binary input signal >Op. mode 'Dir.cls.cmd' (see Figure 6-77).

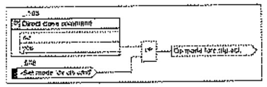


Figure 6-77 Activation of the Operating Mode Direct Close Command

The operating mode Direct close command function initiates a closure release without any testing upon start of the synchronization stage. The closure occurs immediately.

The combination Direct close command with other operating modes is not recommended, as the other operating data is bypassed.

If the synchronization function is defective (standby of the sync stage = alarm or warning), a direct close command is executed or not executed, depending on the type of fault (see also supervisions in chapter 6.4.4 General Functionality).

6.4.12 Interaction with Control and External Triggering

With Control

The control and synchronization function are always located in a function group Circuit breaker. The control and also the synchronization function always operate with the circuit breaker, which is found in the function group Circuit breaker.

As soon as the synchronization function is in the function group Circuit breaker, the circuit breaker is subject to compulsory synchronization. If all synchronization stages are deactivated, the circuit breaker cannot be activated via the control, as no release can be generated for the closure. The circuit breaker is no longer subject to compulsory synchronization after deletion of the synchronization function. Closure without synchronization is then possible via the control.

If closure is to be synchronized via the control, the control automatically generates an internal signal which starts the synchronization function. The functional sequence is described in chapter 6.4.6 Sequence of Functions. After fulfilling all closing conditions, the synchronization sends a release signal to the control, which closes the circuit breaker and then stops the synchronization function.

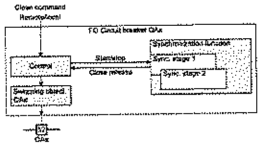


Figure 6-78 Interaction of the Control with the Synchronization Function

With External Control

You have the option of controlling the synchronization function externally via binary input signals. This can be done as follows:

- Edge controlled
- Via the signals >Start sync. process and >Stop sync. process
- State controlled, via the signal >Start / stop syn.proc. (see also chapter 6.4.6 Sequence of Functions).

The start is followed by the functional sequence (see chapter 6.4.6 Sequence of Functions). If the conditions are fulfilled, the output signal Release close cmd. is issued. The switched object QAx of the function group Circuit breaker is not closed. The output signal Release close cmd. must be explicitly assigned to the binary output in order to close the circuit breaker.

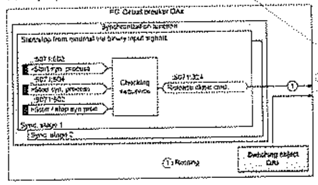


Figure 6-79 Interaction of the Synchronization Function with External Control

6.4.13 Application and Setting Notes (General)

Stage-Type Selection

The following 2 types of stage are available:

Stage Type	Application
Synchrocheck stage	Select this type of stage in cases, for example, an additional release during an manual reclosing for safety reasons. With this type, the variables ΔV, Δf and Δα are checked before connecting the 2 parts of the power system.
Synchronous/asynchronous stage	Select this type of stage if it is necessary to differentiate between synchronous and asynchronous systems, depending on the switch position. If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic for synchronous systems is equality of frequency (Δf ≈ 0). In this state, the conditions Δα and ΔV are checked. If the systems are galvanically isolated, asynchronous systems can be present. At the same time, compliance with the voltage difference ΔV and frequency difference Δf conditions is checked. The time of the direct close command is calculated taking into account the angle difference Δα and the closing time of the circuit breaker. The time of the direct close command is calculated so that the voltages are equal at the moment of pole contact of the circuit breaker (ΔV ≈ 0, Δα ≈ 0).

Configuration of the Voltages V1 (Reference Side) and V2

The voltages V1 and V2 are established via the connection of the measuring points to the interface of the function groups (refer to chapter 6.4.3 Connection and Definition). The measuring point connected to the interface Voltage is the reference side 1 with the reference voltage V1. The measuring point connected to the interface Sync. voltage is the side 2 with V2. The definition of the Delta parameters that can be derived from this is also described in chapter 6.4.3 Connection and Definition.

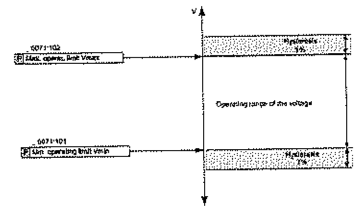
Parameter: Min. operating limit Vmin, Max. operat. limit Vmax

- Recommended setting value (_:5071:101) Min. operating limit Vmin = 90 V
- Recommended setting value (_:5071:102) Max. operat. limit Vmax = 110 V

The values define the voltage operating range of the synchronization stage. A normal setting is approx. ± 10 % of the rated voltage.

NOTE

All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test. Therefore, connected phase-to-ground voltages are multiplied by √3 as the threshold values with reference to the rated voltage (phase-to-phase voltage) must be set.



If the Synchronization function is started within the hysteresis, no switching is performed as a result of the minimum and maximum operating limit (parameters Min. operating limit Vmin and Max. operat. limit Vmax). If the Synchronization function is started within the voltage operating range and the voltage exceeds the minimum or maximum operating limit during the synchronization process, switching can occur in the area of the hysteresis.

Parameter: Max.durat. sync.process

- Default setting (_:5071:110) Max.durat. sync.process = 30 s

The parameterized conditions must be fulfilled within this time. If the conditions are not fulfilled, no further closing release takes place and the synchronization stage is stopped. If this time is set to ∞, the conditions are checked until they are fulfilled. This is also the default setting. Observe the operating conditions when defining the time limitation. This must be defined specifically for each system. If 0 or 0.01 s is set, then all conditions are checked once at the starting time point. Thereafter the process is stopped immediately.

Parameter: Voltage adjustment

- Default setting (_:5071:126) Voltage adjustment = 1.00

The parameter can be used for correction of amplitude errors, for example, due to indirect measurement (for example, tap changer).

To apply a transformer between measuring points, the Voltage adjustment parameter is not needed. The transformer ratios are set for the measuring points and the function will take them into account automatically.

Parameter: Angle adjust. (transform.)

- Default setting (_:2311:127) Angle adjust. (transform.) = 0°

The parameter can be applied under the following conditions:

- 1. Phase-angle rotation by power transformer between the measuring points
- 2. Correction of phase-angle errors

1. Phase-angle rotation by power transformer between the measuring points:

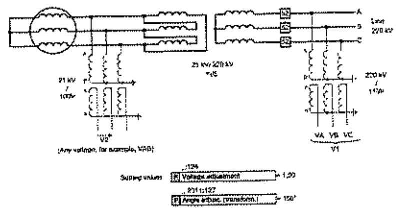


Figure 6-80 Transformer Between the Measuring Points

If there is a power transformer between the voltage transformers of the circuit breaker to be synchronized, you then have to correct the phase-angle rotation for a vector group deviating from 0. Figure 6-80 shows such an application. The Angle adjust. (transform.) parameter is used to save the phase-angle rotation.

The vector group of the transformer is defined by the upper voltage side to the lower voltage side. If the reference voltage transformer V1 is connected on the upper voltage side of the transformer (as in Figure 6-80), enter the phase-angle rotation directly according to the vector group. A vector-group figure of 5, for example, means an angular rotation of 5 · 30° = 150°. Set this value for the Angle adjust. (transform.) parameter.

If the voltage connection V1 is on the lower voltage side due to the system, you then have to apply the extension angle with 360°. A transformer with vector group 4 yields an angular adjustment of 360° – (4 · 30°) = 240°.

2. Correction of phase-angle errors: You can correct a phase-angle error between the voltage transformers in increments. Ascertain a possible correction value during commissioning.

Parameter: CB make time

- Default setting (_:5041:111) CB make time = 0.06 s

If you are to interconnect under asynchronous system conditions with the device as well, the closing time of the circuit breaker must be taken into account. The device uses this to calculate the time of the direct close command, so that the voltages are in phase at the moment of closure of the switch poles. Note that apart from the operating time of the switch, this also includes the pickup time of an auxiliary relay that may be upstream. You can determine the closing time using the protection device (see commissioning notes in chapter 10.2 Primary and Secondary Testing of the Synchronization Function).

This parameter only occurs for the stage type Synchronous/asynchronous.

6.4.14 Application and Setting Notes (Synchrocheck)

Parameter: Maximum Differential Values of Voltage, Frequency and Angle

- Default setting (_:5071:122) Max. voltage diff. V2>V1 = 5.0 V
- Default setting (_:5071:123) Max. voltage diff. V2<V1 = 5.0 V
- Default setting (_:5071:117) Max. frequency diff. f2>f1 = 0.10 Hz

273

- Default setting (_:5071:118) Max. frequency diff. f2<f1 = 0.10 Hz
- Default setting (_:5071:124) Max. angle diff. α2>α1 = 10°
- Default setting (_:5071:125) Max. angle diff. α2<α1 = 10°

2 parameters are available for the differential values voltage, frequency, and angle. Unbalanced closing ranges can be set with this, if required.

The permissible differential values must ensure that no protection tripping or damage occurs in the system owing to compensation processes (circulating current) and power swings after interconnection of the parts of the power system. The settings must not be configured too closely on the other side so that necessary closures are not blocked.

Typical differential values are selected in the default setting. Depending on the system, the settings must be checked and adjusted, if necessary.

6.4.15 Application and Setting Notes (Synchronous/Asynchronous Closure)

Parameter: Synchronous operating mode, Asynchronous operating mode

- Default setting (_:5041:119) Sync. operating mode = off
- Default setting (_:5041:114) Async. operating mode = off

The operating modes of the stages can be activated or deactivated via the parameters. The operating modes are deactivated in the default setting for safety reasons.

The following combinations options are possible:

Sync. operating mode	Async. operating mode	Description
on	on	If the frequency difference is below the threshold value set f-threshold ASYN<->SYN, the operating mode synchronous is active. In other cases, the operating mode asynchronous is active. If you wish to interconnect galvanically isolated systems, then select this operating mode.
off	on	Regardless of the frequency difference and the threshold value f-threshold ASYN<->SYN, the operating mode active is exclusively asynchronous. The closing time of the circuit breaker is thus always taken into account for determining the connecting point. Select this operating mode if you wish to activate machines, for example generators or asynchronous motors. If the same frequency is present on the sides to be interconnected, then this operating mode is not possible. Since, in the case of dependency on the phase-angle position (Δα), release of the closure may not be issued.
on	off	Use this operating mode for galvanically connected systems. Closure is only possible with synchronous systems (with low Δf).

Sync. operating mode	Async. operating mode	Description
off	off	Both operating modes are deactivated. No closing release can be therefore be given via this operating mode. This configuration is only advisable for special applications. Select this operating mode if you only wish to switch, for example de-energized parts of the power system.

Parameter for asynchronous operation: Max. voltage diff. of voltage and frequency

- Default setting (_:5041:115) Max. voltage diff. V2>V1 = 2.0 V
- Default setting (_:5041:116) Max. voltage diff. V2<V1 = 2.0 V
- Default setting (_:5041:117) Max. frequency diff. f2>f1 = 0.10 Hz
- Default setting (_:5041:118) Max. frequency diff. f2<f1 = 0.10 Hz

For information, see Parameter for synchronous operation

Parameter for synchronous operation: Maximum voltage diff. of voltage and angle

- Default setting (_:5041:122) Max. voltage diff. V2>V1 = 5.0 V
- Default setting (_:5041:123) Max. voltage diff. V2<V1 = 5.0 V
- Default setting (_:5041:124) Max. angle diff. α2>α1 = 10°
- Default setting (_:5041:125) Max. angle diff. α2<α1 = 10°

2 parameters are available for the differential values voltage, frequency, and angle. Unbalanced closing ranges can be set with this, if required.

The permissible differential values must ensure that no protection tripping or damage occurs in the system owing to compensation processes (circulating current) and power swings after interconnection of the parts of the power system. The settings must not be configured too closely on the other side so that necessary closures are not blocked.

Typical differential values are selected in the default setting. Depending on the system, the settings must be checked and adjusted, if necessary.

Parameter: Switchover between synchronous and asynchronous operation

- Recommended setting value (_:5041:120) f-threshold ASYN<->SYN = 0.01 Hz

This parameter is used to set the frequency difference for switching over between synchronous and asynchronous operation.

Siemens recommends using the default setting of 0.01 Hz.

6.4.16 Application and Setting Notes (De-Energized Switching/Direct Close Command)

If at least one of 2 parts of an electrical power system is de-energized, the parts of the electrical power system can be connected together via the following operating modes. The above potential release conditions are independent of one another and can also be combined.

NOTE

For reasons of safety, the releases have been deactivated in the default setting and are therefore at no. Even if you wish to apply one of these operating modes, Siemens recommends leaving the setting at no for reasons of safety. Set the operating mode only dynamically via the assigned binary input signal (for example >Operating mode ... (see also Figure 6-74)). This prevents one of these operation modes from being incorrectly activated statically thereby resulting in an incorrect switching.

Parameter: Close cmd. at V1< & V2>

- Recommended setting value (_:5071:105) Close cmd. at V1< & V2> = no

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If part V1 of the power system is de-energized and part V2 of the power system is energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: Close cmd. at V1> & V2<

- Recommended setting value (_:5071:106) Close cmd. at V1> & V2< = no

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If part V1 of the power system is energized and part V2 of the power system is de-energized, the release for closure is given upon starting the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: Close cmd. at V1< & V2<

- Recommended setting value (_:5071:107) Close cmd. at V1< & V2< = no

Settings	Description
no	No release for closing is possible via this operating mode.
yes	If the parts V1 and V2 of the power system are de-energized, the release for closure is given upon start on the synchronization stage after the supervision time has passed. The setting depends on the operational requirements. Note the above information.

Parameter: V1, V2 with voltage

- Recommended setting value (_:5071:104) V1, V2 with voltage = 80 V

The setting value indicates the voltage above which a part of the power system (feeder or busbar) can be regarded as activated with certainty.

You must set the value below the minimum expected operational undervoltage. Siemens therefore recommends a setting value of approx. 80 % of the rated voltage. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test.

Parameter: V1, V2 without voltage

- Recommended setting value (_:5071:103) V1, V2 without voltage = 5 V

The setting value indicates the voltage below which a part of the power system (feeder or busbar) can be regarded as deactivated with certainty.

Siemens recommends a setting value of approx. 5 % of the rated voltage for this. All voltages connected according to the parameterized measuring-point connection type are subjected to the appropriate Vmin/Vmax test.

Parameter: Supervision time

- Recommended setting value (_:5071:109) Supervision time = 0.1 s

The parameter defines a supervision time for which the above additional closing conditions have to be at least fulfilled at de-energized switching, before the release for closing is given, in order to include transient phenomena. Siemens recommends a value of 0.1 s.

Parameter: Direct close command

- Recommended setting value (_:5071:108) Direct close command = no

In this operating mode, the function initiates a closing release without any testing upon start of the synchronization stage. The closure occurs immediately.

NOTE

For safety reasons, Siemens recommends leaving the setting at no. If a direct close command is necessary, Siemens recommends only using this operating mode dynamically via the binary input signal >Op. mode "dir.cls.cmd" (see also Figure 6-74). This prevents this operating mode from being incorrectly activated statically thereby resulting in an incorrect switching.

6.4.17 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:127	General:Angle adjust. (transform.)		-179.0° to 180.0°	0.0°
General				
_:5071:1	Synchrocheck 1:Mode		• off • on • test	off
_:5071:101	Synchrocheck 1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5071:102	Synchrocheck 1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5071:110	Synchrocheck 1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5071:508	Synchrocheck 1:Direct close command		• no • yes	no
_:5071:126	Synchrocheck 1:Voltage adjustment		0.500 to 2.000	1.000
De-energized switch.				
_:5071:105	Synchrocheck 1:Close cmd. at V1< & V2>		• no • yes	no
_:5071:106	Synchrocheck 1:Close cmd. at V1> & V2<		• no • yes	no
_:5071:107	Synchrocheck 1:Close cmd. at V1< & V2<		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:5071:103	Synchrocheck 1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5071:104	Synchrocheck 1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5071:109	Synchrocheck 1:Supervision time		0.00 s to 60.00 s	0.1 s
Synchr. conditions				
_:5071:122	Synchrocheck 1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5071:123	Synchrocheck 1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5071:117	Synchrocheck 1:Max. frequency diff. f2>f1		0.000 Hz to 2.000 Hz	0.100 Hz
_:5071:118	Synchrocheck 1:Max. frequency diff. f2<f1		0.000 Hz to 2.000 Hz	0.100 Hz
_:5071:124	Synchrocheck 1:Max. angle diff. α2>α1		0° to 90°	10°
_:5071:125	Synchrocheck 1:Max. angle diff. α2<α1		0° to 90°	10°
General				
_:5041:1	Sychr./Asyn. 1:Mode		• off • on • test	off
_:5041:101	Sychr./Asyn. 1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5041:102	Sychr./Asyn. 1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5041:110	Sychr./Asyn. 1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5041:508	Sychr./Asyn. 1:Direct close command		• no • yes	no
_:5041:126	Sychr./Asyn. 1:Voltage adjustment		0.500 to 2.000	1.000
De-energized switch.				
_:5041:105	Sychr./Asyn. 1:Close cmd. at V1< & V2>		• no • yes	no
_:5041:106	Sychr./Asyn. 1:Close cmd. at V1> & V2<		• no • yes	no
_:5041:107	Sychr./Asyn. 1:Close cmd. at V1< & V2<		• no • yes	no
_:5041:103	Sychr./Asyn. 1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5041:104	Sychr./Asyn. 1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5041:109	Sychr./Asyn. 1:Supervision time		0.00 s to 60.00 s	0.1 s
Asynchr. op. mode				
_:5041:114	Sychr./Asyn. 1:Async. operating mode		• off • on	on
_:5041:113	Sychr./Asyn. 1:CB make time		0.01 s to 0.60 s	0.06 s

Addr.	Parameter	C	Setting Options	Default Setting
_:5041:115	Sychr./Asyn. 1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:116	Sychr./Asyn. 1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:117	Sychr./Asyn. 1:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:5041:118	Sychr./Asyn. 1:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
Synchr. op. mode				
_:5041:119	Sychr./Asyn. 1:Sync. operating mode		• off • on	on
_:5041:120	Sychr./Asyn. 1:f-threshold ASYN<->SYN		0.010 Hz to 0.200 Hz	0.010 Hz
_:5041:122	Sychr./Asyn. 1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:123	Sychr./Asyn. 1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:124	Sychr./Asyn. 1:Max. angle diff. α2>α1		0° to 90°	10°
_:5041:125	Sychr./Asyn. 1:Max. angle diff. α2<α1		0° to 90°	10°
_:5041:121	Sychr./Asyn. 1:Delay close command		0.00 s to 60.00 s	0.00 s
df/dt/dv limitation				
_:140	Adv. options:Limit df/dt/dv for sync. op.		• 0 • 1	false
_:141	Adv. options:Max. value df/dt/dv syn		0.010 Hz/s to 0.025 Hz/s	0.050 Hz/s
_:142	Adv. options:Limit df/dt/dv for asyn. op.		• 0 • 1	false
_:143	Adv. options:Max. value df/dt/dv asyn		0.050 Hz/s to 0.500 Hz/s	0.050 Hz/s
Frequ. oscillations				
_:150	Adv. options:Suppr. frequ. oscillations		• 0 • 1	false
_:151	Adv. options:Max. diff. "f threshold"		0.000 Hz to 0.500 Hz	0.000 Hz

6.4.18 Information List

No.	Information	Data Class (Type)	Type
Measurements			
_:2311:303	General:Multiple select. op	SPS	O
_:2311:304	General:Selected no V selected	SPS	O
_:2311:329	General:dV	MV	O
_:2311:330	General:f1	MV	O
_:2311:331	General:V2	MV	O
_:2311:332	General:f2	MV	O
_:2311:300	General:dV	MV	O

274

No.	Information	Data Class (Type)	Type
_:2311:301	Control.BI	MV	O
_:2311:302	Control.BI	MV	O
Synchrocheck 1			
_:5071:81	Synchrocheck 1:>Block stage	SPS	I
_:5071:500	Synchrocheck 1:>Selection	SPS	I
_:5071:501	Synchrocheck 1:>Start / stop syn.proc.	SPS	I
_:5071:503	Synchrocheck 1:>Start syn. process	SPS	I
_:5071:504	Synchrocheck 1:>Stop syn. process	SPS	I
_:5071:506	Synchrocheck 1:>Op. mode 'V1>V2<'	SPS	I
_:5071:505	Synchrocheck 1:>Op. mode 'V1<V2>'	SPS	I
_:5071:507	Synchrocheck 1:>Op. mode 'V1<V2<'	SPS	I
_:5071:508	Synchrocheck 1:>Op. mode 'dir.ch.cmd'	SPS	I
_:5071:502	Synchrocheck 1:>Block close command	SPS	I
_:5071:54	Synchrocheck 1:Inactive	SPS	O
_:5071:52	Synchrocheck 1:Behavior	ENS	O
_:5071:53	Synchrocheck 1:Health	ENS	O
_:5071:328	Synchrocheck 1:In progress	SPS	O
_:5071:324	Synchrocheck 1:Release close cmd.	SPS	O
_:5071:302	Synchrocheck 1:All sync. conditio. OK	SPS	O
_:5071:325	Synchrocheck 1:Voltage difference OK	SPS	O
_:5071:326	Synchrocheck 1:Angle difference OK	SPS	O
_:5071:327	Synchrocheck 1:Frequency diff. OK	SPS	O
_:5071:307	Synchrocheck 1:Cond. V1>V2< fulfilled	SPS	O
_:5071:306	Synchrocheck 1:Cond. V1<V2> fulfilled	SPS	O
_:5071:308	Synchrocheck 1:Cond. V1<V2< fulfilled	SPS	O
_:5071:309	Synchrocheck 1:Frequency f1 > fmax	SPS	O
_:5071:310	Synchrocheck 1:Frequency f1 < fmin	SPS	O
_:5071:311	Synchrocheck 1:Frequency f2 > fmax	SPS	O
_:5071:312	Synchrocheck 1:Frequency f2 < fmin	SPS	O
_:5071:313	Synchrocheck 1:Voltage V1 > Vmax	SPS	O
_:5071:314	Synchrocheck 1:Voltage V1 < Vmin	SPS	O
_:5071:315	Synchrocheck 1:Voltage V2 > Vmax	SPS	O
_:5071:316	Synchrocheck 1:Voltage V2 < Vmin	SPS	O
_:5071:317	Synchrocheck 1:V diff.too large(V2>V1)	SPS	O
_:5071:318	Synchrocheck 1:V diff.too large(V2<V1)	SPS	O
_:5071:319	Synchrocheck 1:f diff.too large(f2>f1)	SPS	O
_:5071:320	Synchrocheck 1:f diff.too large(f2<f1)	SPS	O
_:5071:321	Synchrocheck 1:α diff.too large(α2>α1)	SPS	O
_:5071:322	Synchrocheck 1:α diff.too large(α2<α1)	SPS	O
_:5071:304	Synchrocheck 1:Max. time exceeded	SPS	O
_:5071:323	Synchrocheck 1:Setting error	SPS	O
Synchr./Async. 1			
_:5041:81	Synchr./Async. 1:>Block stage	SPS	I
_:5041:500	Synchr./Async. 1:>Selection	SPS	I
_:5041:502	Synchr./Async. 1:>Start / stop syn.proc.	SPS	I
_:5041:503	Synchr./Async. 1:>Start syn. process	SPS	I

No.	Information	Data Class (Type)	Type
_:5041:501	Synchr./Async. 1:>Stop syn. process	SPS	I
_:5041:506	Synchr./Async. 1:>Op. mode 'V1>V2<'	SPS	I
_:5041:505	Synchr./Async. 1:>Op. mode 'V1<V2>'	SPS	I
_:5041:507	Synchr./Async. 1:>Op. mode 'V1<V2<'	SPS	I
_:5041:508	Synchr./Async. 1:>Op. mode 'dir.ch.cmd'	SPS	I
_:5041:504	Synchr./Async. 1:>Block close command	SPS	I
_:5041:54	Synchr./Async. 1:Inactive	SPS	O
_:5041:52	Synchr./Async. 1:Behavior	ENS	O
_:5041:53	Synchr./Async. 1:Health	ENS	O
_:5041:328	Synchr./Async. 1:In progress	SPS	O
_:5041:324	Synchr./Async. 1:Release close cmd.	SPS	O
_:5041:300	Synchr./Async. 1:All sync. conditio. OK	SPS	O
_:5041:329	Synchr./Async. 1:State f-synchronous	SPS	O
_:5041:325	Synchr./Async. 1:Voltage difference OK	SPS	O
_:5041:326	Synchr./Async. 1:Angle difference OK	SPS	O
_:5041:327	Synchr./Async. 1:Frequency diff. OK	SPS	O
_:5041:307	Synchr./Async. 1:Cond. V1>V2< fulfilled	SPS	O
_:5041:306	Synchr./Async. 1:Cond. V1<V2> fulfilled	SPS	O
_:5041:308	Synchr./Async. 1:Cond. V1<V2< fulfilled	SPS	O
_:5041:309	Synchr./Async. 1:Frequency f1 > fmax	SPS	O
_:5041:310	Synchr./Async. 1:Frequency f1 < fmin	SPS	O
_:5041:311	Synchr./Async. 1:Frequency f2 > fmax	SPS	O
_:5041:312	Synchr./Async. 1:Frequency f2 < fmin	SPS	O
_:5041:313	Synchr./Async. 1:Voltage V1 > Vmax	SPS	O
_:5041:314	Synchr./Async. 1:Voltage V1 < Vmin	SPS	O
_:5041:315	Synchr./Async. 1:Voltage V2 > Vmax	SPS	O
_:5041:316	Synchr./Async. 1:Voltage V2 < Vmin	SPS	O
_:5041:317	Synchr./Async. 1:V diff.too large(V2>V1)	SPS	O
_:5041:318	Synchr./Async. 1:V diff.too large(V2<V1)	SPS	O
_:5041:319	Synchr./Async. 1:f diff.too large(f2>f1)	SPS	O
_:5041:320	Synchr./Async. 1:f diff.too large(f2<f1)	SPS	O
_:5041:321	Synchr./Async. 1:α diff.too large(α2>α1)	SPS	O
_:5041:322	Synchr./Async. 1:α diff.too large(α2<α1)	SPS	O
_:5041:304	Synchr./Async. 1:Max. time exceeded	SPS	O
_:5041:323	Synchr./Async. 1:Setting error	SPS	O

6.4.19 External Synchronization

The purpose of the External synchronization function is to control an external synchronization device.

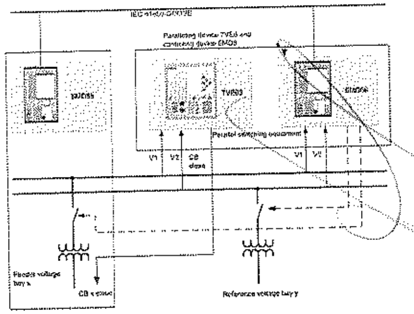


Figure 6-81 Triggering an External Synchronization Device

The bay controller in bay x should switch the circuit breaker in bay x in synchrony. The synchronization check is carried out in the central paralleling device 7VE6. In addition to the paralleling device, another central bay controller ensures the switching of the correct measuring voltages and the routing of the CB close command from the 7VE6 to the correct circuit breaker in bay x. The bay controller x provides the information to the central bay controller via IEC61850-GOOSE.

The External synchronization is designed as a function block which can be used in the Circuit-breaker function group. The additional External synchronization function block integrates the external synchronization into command processing, so that the corresponding feedback can be forwarded to the command source.

If a circuit-breaker close command with a synchronization requirement is present, the external synchronization device is started. After successfully checking the synchronization conditions, the close command is issued from the external synchronization device to the circuit breaker. If a circuit-breaker close command without synchronization requirement is present, the circuit-breaker close command is issued directly from the Circuit-breaker function group to the circuit breaker. Also, each circuit breaker trip command is issued directly to the circuit breaker.

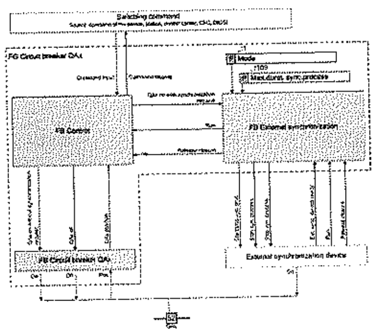


Figure 6-82 Interaction between Control and External Synchronization

Parameterization with DIGSI

In the DIGSI library, the function is visible inside the Circuit-breaker function group as the External synchronization function block. You can instantiate the function block in the Circuit-breaker function group and the Circuit-breaker (control) function group. You can instantiate only 1 External synchronization function block within these function groups at a time.

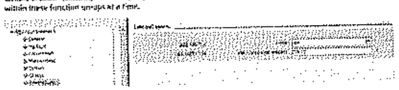


Figure 6-83 Instantiating the External Synchronization Function Block in the Circuit-Breaker Function Group

It is not possible to jointly instantiate the External synchronization function block with the 25 synchronization function in the same Circuit-breaker function group.

Notes for Optional Input Interconnections

You have the option of connecting the input signals *>Close cmd. released* and *>In progress*. If you omit these interconnections, observe the following instructions:

Input *>Close cmd. released*:

If you do not interconnect the input signal *>Close cmd. released*, the execution of a circuit breaker close command with synchronization requirement is confirmed directly (execution successful: OPR+), as soon as the output signal *Start syn. process* is set. In this case, the (_:109) Max.durat. sync.process setting has no meaning. If you use a control model with feedback monitoring, consider that the feedback monitoring will start immediately when the *Start syn. process* signal is tripped. The (_:4201:102) Feedback monitoring time setting must therefore be set higher than the maximum synchronization time of the external synchronization device plus the circuit-breaker closing time. If *>Close cmd. released* is not routed, the output *Start/stop syn. proc.* is not set.

Input *>In progress*:

The interconnection of the input signal *>In progress* is intended to check whether the synchronization device has received the *Start syn. process* signal. If you do not interconnect this input signal and the external synchronization device rejects a start command, the negative acknowledgment of the circuit-breaker close command does not occur until the maximum synchronization time (parameter (_:109) Max.durat. sync.process) has expired.

6.4.20 Application and Setting Notes (External Synchronization)

Parameter: Mode

- Default setting (_:1) Mode = on

With the Mode setting, you switch the external synchronization function on or off. If you set the Mode setting to *off*, a circuit-breaker close command with synchronization requirement is rejected.

Parameter: Max.durat. sync.process

- Default setting (_:109) Max.durat. sync.process = 30 s

The Max.durat. sync.process setting defines the maximum synchronization time. The time starts when the External synchronization function block sends a close command to the external synchronization device. The command must be executed within this time. If the close command is not executed within this time, the External synchronization function block sends a command to cancel closing to the external synchronization device.

6.4.21 Settings

Addr.	Parameter	C	Setting Options	Default Setting
External synch.				
_:1	External synch.:Mode		• off • on • test	on
_:109	External synch.:Max.durat. sync.process		0.00 s to 3600.00 s	30.00 s

6.4.22 Information List

No.	Information	Data Class (Type)	Type
External synch.			
_:52	External synch.:Behavior	ENS	O
_:54	External synch.:Health	ENS	O
_:55	External synch.:Start syn. process	SPS	O
_:56	External synch.:Stop syn. process	SPS	O
_:57	External synch.:Start/stop syn. proc.	SPS	O
_:506	External synch.:>Synch. device ready	SPS	I
_:507	External synch.:>Close cmd. released	SPS	I
_:508	External synch.:>In progress	SPS	I

6.5 Switching Sequences

6.5.1 Overview of Functions

Switching sequences may be running inside the device that switch the switchgear automatically in a prespecified sequence.

A switching sequence consists of a special function block Switching sequence (Swi. seq.) from the DIGSI 5 library and the project-specific list of the switching commands that are generated in the CFC.

6.5.2 Function Description

The function block Switching sequence is located in folder User-defined functions in the DIGSI 5 Library.

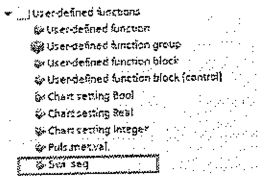


Figure 6-84 Function block Switching Sequence in the Library

These function blocks can be used in the information matrix on the highest level (level of the function groups) or in a user-defined function group.

One Switching sequence function block is used per switching sequence. The function block is the interface for controlling and monitoring the condition of the CFC switching sequence. The task of the function block is to verify the relative conditions for control commands, for example, switching authority, interlocking conditions, etc. You can connect the signals of the function block with the CFC chart. They start and stop the switching sequence and provide data about the status of the switching sequence (see Figure 6-85). The CFC chart is used to activate the switching device that must be switched. The CFC blocks define, among other things, the switching devices that must be switched.

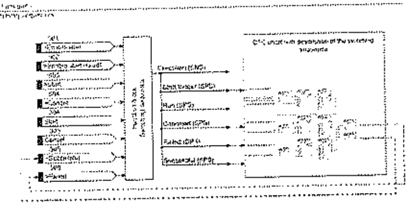


Figure 6-85 Switching Sequence Function Block

Starting and Cancelling a Switching Sequence

One of the following methods can be used to start a switching sequence:

- On-site operation: menu or display page
- Input >Start during rising edge, for example, via binary input
- Controllable Start for the start via a communication protocol, for example, IEC 61850, T103, or DNP
- Input >Start via a function key
- Controllable Start via a function key

One of the following methods can be used to cancel a switching sequence:

- On-site operation: menu or display page
- Input >Cancel during rising edge, for example, via binary input
- Controllable Cancel for the cancellation via a communication protocol, for example, IEC 61850, T103, or DNP
- Input >Cancel via a function key
- Controllable Cancel via a function key

On-Site Operation

If at least one Switching sequence function block is used in the device, a new Switching sequences entry is shown in the first line of the Control menu. If this menu item is selected, an overview of all switching sequences and their current status will be displayed (see Figure 6-86, example with 2 switching sequences). You can start or cancel the switching sequences from this menu.

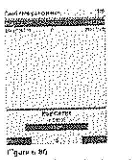


Figure 6-86 Overview of the Switching Sequences on the Device Display

6.5.3 Application and Setting Notes

The function block offers 4 other settings as the Control function block of a circuit breaker or disconnector (see chapter 6.2.2 General Overview).

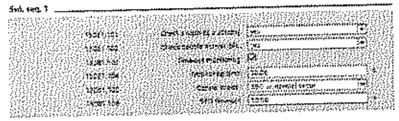


Figure 6-87 Settings of the Switching Sequence Function Block

Parameter: Check switching authority

- Default setting (_:101) Check switching authority = yes

With the Check switching authority parameter, you can determine whether the switching authority should be checked before the execution of the switching sequence.

Parameter: Check double activat. blk.

- Default setting (_:102) Check double activat. blk. = yes

With the Check double activat. blk. parameter, you can determine whether the double activation of switching devices should be checked. The setting value yes indicates that a switching sequence will be started only if no switching command for a circuit breaker and disconnector are activated, provided that double activation blocking was activated for those switching devices.

Parameter: Time-out monitoring

With the Time-out monitoring parameter, you can determine whether the feedback from the process should be evaluated. The feedback is gathered via the inputs >Successful and >Failed.

Parameter: Monitoring time

- Default setting (_:104) Monitoring time = 30.00 s

With the Monitoring time parameter, you can determine the duration of the monitoring time.

Parameter: Control model

- Default setting (_:105) Control model = SBO w. normal secur.

With the Control model parameter, you select between direct w. normal secur. or SBO w. normal secur. to start the switching sequence.

It is not possible to set a control model for cancelation of the switching sequence. The control model direct w. normal secur. is always used to cancel the function.

Information

The Switching sequence function block provides the following data:

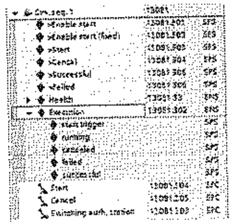


Figure 6-88 Data Provided by the Switching Sequence Function Block

In the Switching sequence function block, the interlocking is analog to the interlocking function block and it is possible to use it in the switching sequence:

- >Enable start: Connection to interlocking conditions (CFC) for the start of the entire switching sequence, has no effect in the non-interlocked switching mode.
- >Enable start (fixed): Non revocable interlocking condition for the start of the entire switching sequence, in effect regardless of the switching mode.

If the time-out monitoring is activated (parameter Time-out monitoring), the process feedback must take place via the inputs >Successful and >Failed. If the last switching command of the switching sequence was executed successfully, the input >Successful usually is set. To do this, connect the feedback of the last switching command from the CFC with this input of the function block during the device parameterization.

If a switching command fails, this feedback can be captured by the input >Failed. The active switching sequence will be ended immediately and does not have to wait for a time out.

The indication Execution signals the current condition of the switching sequence. The events running, canceled, failed, and successful are generated only while the time-out monitoring is activated. The event Start Triggered used to start the switching sequence in the CFC chart.

Example for a Switching Sequence with CFC

The following figure shows a single-line diagram for a substation with 4 bays: Busbar grounding, infeed, bus coupler, and feeder bay.

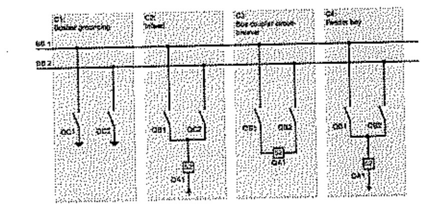


Figure 6-89 Example of a Substation

The switching sequence C4 Off (Figure 6-90) should switch off feeder bay C4. The circuit breaker is opened, followed by opening of one of the 2 busbar disconnectors.

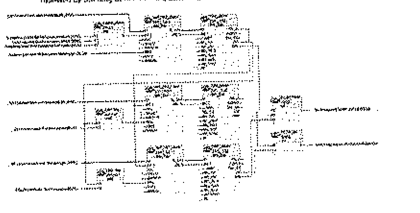


Figure 6-90 CFC Switching Sequence C4 Off

Command Execution

As described in section Starting and Cancelling a Switching Sequence, Page 356, the display page or the Control menu can be used to start the switching sequence. The Start Trigger signal for indication Execution is used to recognize the start and initiates the switching sequence by pickup of TRIG in the DPC DEF building block of circuit breaker QA1. Building blocks DPC DEF and DPC EXE are always used in pairs. The DEF building block controls the type and extent of the command:

- VAL = Switching direction (0 = Off, 1 = On)
- SELECT = Select switching device (2 = Select with a value suitable for the preset control model SBO w. enh. security)
- OPERATE = Switch switching device (1 = Switching device is switched on or off)

Using the connected DPC EXE building block, the command checks can be deactivated (REL_...). In the application example, all inputs are set to 0 and therefore, all checks are activated.

After the open command of circuit breaker QA1 is acknowledged via the auxiliary contacts, the OK output of the CFC block DPC_EXE becomes active and triggers the next switching object. With the input FT the signal for the OK output is time-delayed (in the example by 10 ms) and creates a dead time between individual switching commands and the switching sequence. This dead time is important for the updating of the interlocking conditions.

If QB1 is closed, QB1 will be opened. If QB2 is closed, QB2 will be opened. In order to implement this logic, the OK output signal of QA1 is linked with the respective positions of circuit breaker QB1 and QB2 via the logical AND function. This signal serves as a trigger for the trip command of QB1 or QB2.

Because in this example the time-out monitoring is activated, the feedback about the successful or unsuccessful execution of the switching sequence must be parameterized. The Switching sequence function block provides the inputs >Successful and >Failed. In order to acknowledge the entire switching sequence positively, the OR operation of the OK outputs for the disconnectors QB1 and QB2 is sufficient. The feedback of all failed executions takes place via the OR operation of all ERR outputs of the switching devices. The benefit of such assessment is the fact that, in case of a failure, waiting for the time-out is not necessary, but the active switching sequence can be ended immediately.

In this example, the use of the EN_I input of building block DPC-DEF fulfills 2 tasks:

- Cancelation of the entire switching sequence
- Resetting of the outputs OK and ERR on building block DPC-EXE

By linking all EN_I inputs and EN_O outputs of building blocks DPC DEF and DPC EXE, the execution of the switching sequence can be controlled centrally since the value is transmitted between the building blocks. Only if input EN_I on the DPC EXE is set to 1, a switching command is issued. If the input drops back to 0 while a command is being processed, this command will be canceled. With this behavior, cancelation of an entire switching sequence can be achieved. As recognition of a cancelation, the cancel feedback of the indication Execution is used in the CFC chart and connected with the input EN_I of the first switching device, in this example, with the DPC-DEF building block of circuit breaker QA1.

Since the OK and ERR outputs of the DPC-EXE building block maintain their value until execution of the next command, it is necessary to reset the continuous output after each execution of the switching sequence for correct execution of the entire CFC switching sequence multiple times. In this case, the use of the EN_I input is also helpful. If the input drops back to 0, the OK and ERR outputs are also reset to 0. The triggers for ending the switching sequence are the events failed and successful. For this reason, in the above example, the signals failed and successful of the indication Execution were connected with EN_I of the DPC-DEF building block.

6.5.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Swi. seq. #				
_:101	Swi. seq. #:Check switching authority		• no • yes • advanced	yes

Addr.	Parameter	C	Setting Options	Default Setting
_:102	Swi. seq. #:Check double activat. blk.		• no • yes	yes
_:103	Swi. seq. #:Time out monitoring		• 0 • 1	true
_:104	Swi. seq. #:Monitoring time		0.01 s to 1800.00 s	30.00 s
_:105	Swi. seq. #:Control model		• direct w. normal secur. • SBO w. normal secur.	SBO w. normal secur.
_:106	Swi. seq. #:SBO time out		0.01 s to 1800.00 s	30.00 s
Switching authority				
_:151	Swi. seq. #:Swi.dev. related sw.auth.		• 0 • 1	false
_:152	Swi. seq. #:Specific sw. authorities		• 0 • 1	true
_:115	Swi. seq. #:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:153	Swi. seq. #:Num. of specific sw.auth.		2 to 5	2
_:154	Swi. seq. #:Multiple specific sw.auth.		• 0 • 1	false

6.5.5 Information List

No.	Information	Data Class (Type)	Type
Swi. seq. #			
_:501	Swi. seq. #:>Enable start	SPS	I
_:502	Swi. seq. #:>Enable start (fixed)	SPS	I
_:503	Swi. seq. #:>Start	SPS	I
_:504	Swi. seq. #:>Cancel	SPS	I
_:505	Swi. seq. #:>Successful	SPS	I
_:506	Swi. seq. #:>Failed	SPS	I
_:53	Swi. seq. #:Health	ENS	O
_:302	Swi. seq. #:Execution	ENS	O
_:304	Swi. seq. #:Start	SPC	C
_:305	Swi. seq. #:Cancel	SPC	C

6.6 User-Defined Function Block [Control]

6.6.1 Overview of Functions

The User-defined function block [control] allows the switching authority check of a control command and the check of whether the circuit breaker has reached the position for user-defined controllables.

6.6.2 Function Description

The User-defined function block [control] is located in the folder User-defined functions in the DIGSI 5 Library.

You can instantiate the user-defined function block on the top level (equivalent to other function groups) as well as within function groups and functions.

The task of the function block is to check the switching authority. For control commands, the function block checks whether the switching direction is the same as the current switch position. You can instantiate every user-defined signal (for example, SPS, DPC, BSC) in the function block and route the corresponding indications (see following figure).

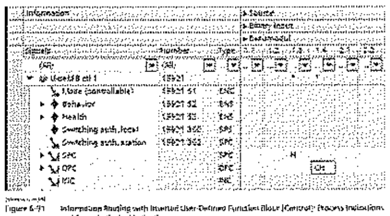


Figure 6-91 Information Routing with Inserted User-Defined Function Block [Control]: Process Indications and Some Individual Indications

6.6.3 Application and Setting Notes

The function block contains the parameters (_:104) Check switching authority and (_:105) Check if pos. is reached as shown in the following figure. The parameter settings affect all controllables instantiated in the function block. Other signal types are not affected by these parameters and objects.

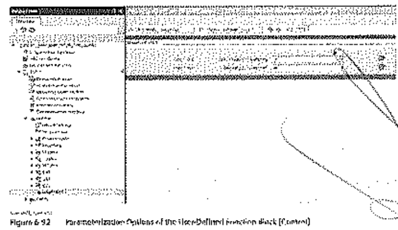


Figure 6-92 Parameterization Options of the User-Defined Function Block [Control]

Parameter: Check switching authority

- Default setting (_:104) Check switching authority = yes

With the Check switching authority parameter, you determine whether the command source of switching commands must be checked (see chapter 6.3.1 Command Checks and Switchgear Interlocking Protection).

Parameter: Check if pos. is reached

- Default setting (_:105) Check if pos. is reached = yes

With the Check if pos. is reached parameter, you check at a switching command whether the switching direction equals the current position.

6.6.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
U-def. FB ctl.#				
_:104	U-def.FB ctl.#:Check switching authority		• no • yes	yes
_:105	U-def.FB ctl.#:Check if pos. is reached		• no • yes	yes

6.6.5 Information List

No.	Information	Data Class (Type)	Type
U-def. FB ctl.#			
_:51	U-def.FB ctl.#:Mode (controllable)	ENC	C
_:52	U-def.FB ctl.#:Behavior	ENS	O
_:53	U-def.FB ctl.#:Health	ENS	O
_:300	U-def.FB ctl.#:Switching auth. local	SPS	O
_:302	U-def.FB ctl.#:Switching auth. station	SPC	C

6.7 CFC-Chart Settings

6.7.1 Overview of Functions

If you want to process a parameter in a CFC chart and this parameter is to be changeable via DIGSI or HMI during runtime, you can use the function blocks Chart setting Bool, Chart setting integer, and Chart setting Real. Instantiate the appropriate function block depending on the needed parameter value (logical, integer, or floating point).

6.7.2 Function Description

You can find the CFC-chart parameters Chart setting Bool, Chart setting Int, and Chart setting Real in the DIGSI library in the User-defined functions folder. Drag and drop the desired function block into a function group or a function. Set the appropriate parameter value of the function block in DIGSI using the parameter editor or via HMI under the Settings menu item. You can then use the parameter as an input signal in CFC charts.

NOTE

The user-defined function groups and the user-defined functions can be used to group the CFC chart parameters. You can rename for the function block and change the parameter value in the DIGSI information routing matrix to suit your specific application.

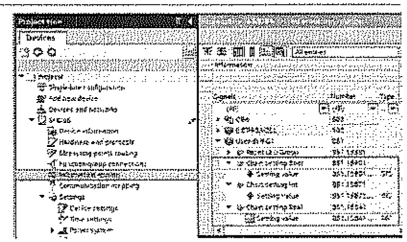


Figure 6-93 CFC-Chart Parameters Within Information Routing

6.7.3 Application and Setting Notes

Parameter: Chart setting Bool

- Default setting Chart setting Bool = false

You can use the parameter Chart setting Bool in a CFC chart as an input signal with a Boolean value. This input value can then be changed during the runtime of the CFC chart.

Parameter: Chart setting Int

- Default setting Chart setting Int = 10

You can use the parameter Chart setting Int in a CFC chart as an input signal with an integer value. This input value can then be changed during the runtime of the CFC chart.

Parameter: Chart setting Real

- Default setting Chart setting Real = 100.000

You can use the parameter Chart setting Real in a CFC chart as an input signal with a floating-point number. This input value can then be changed during the runtime of the CFC chart.

6.7.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Bool				
_:105	Chart setting Bool:Value		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Int				
_:105	Chart setting Int:Value		-2147483648 to 2147483647	10

Addr.	Parameter	C	Setting Options	Default Setting
Chart setting Real				
_:105	Chart setting Real:Value		-10000000000.000 % to 10000000000.000 %	100.000 %

6.7.5 Information List

No.	Information	Data Class (Type)	Type
Chart setting Bool			
_:305	Chart setting Bool:Setting value	SPS	O

No.	Information	Data Class (Type)	Type
Chart setting Int			
_:305	Chart setting Int:Setting value	INS	O

No.	Information	Data Class (Type)	Type
Chart setting Real			
_:305	Chart setting Real:Setting value	MV	O

6.8 Transformer Tap Changers

6.8.1 Function Description

With the device control function, you can change a transformer tap by moving it higher or lower and monitor the proper execution of the adjusting commands.

The function has built-in comprehensive options for measuring the tap changer position as well as supervision functions. The supervision functions are used to check the voltage and supply information about the tap position for adaptive matching of the transformer differential protection.

The following options are provided for control:

- Direct user commands via the device keypad or routed binary inputs
- User defined conditions via the CFC

If the tap changer reaches the end positions, the control function issues the (_:302) End higher pos. reached or (_:303) End lower pos. reached indication.

The transformer tap controller is controlled by the function group Tap changer, which you can select from the DIGSI library (group Switching devices).

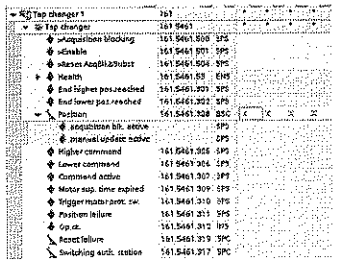


Figure 6-94 Tap Changer Functionality in the DIGSI Information Matrix

The central element is the Controllable Position of type BSC (Binary Controlled Step Position Information, based on IEC 61850). You connect this Controllable in the matrix to the desired number of binary inputs that indicate the current tap position.

You can find more information in chapter 6.8.2 Application and Setting Notes.

The Position Controllable also contains settings. If you wish to change the settings, you must select the Controllable in the DIGSI information matrix and change the settings by way of the Properties dialog. The taps are controlled via the commands Higher command and Lower command, each of which must be connected to one binary output.

Example

The following 2 figures show a CFC chart as an example for transformer tap control with the routing of the function keys for stepping up or stepping down.

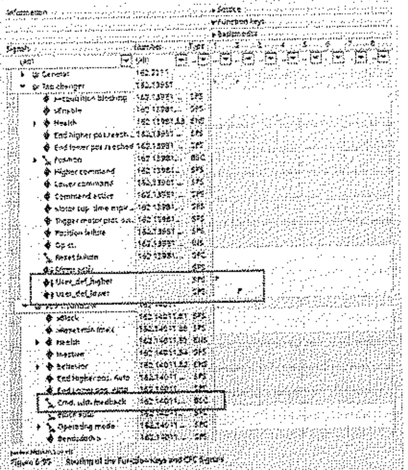


Figure 6-95 Routing of the Function Keys and CFC Signals

To use the function keys, you create 2 user-defined single-point indications (SPS). These are used for the function keys (for example, <F5>, higher function key and <F6>, lower function key) and as the input signals for the appropriate CFC blocks. In addition, you must use the controllable Cmd. with feedback for the CFC chart.

You can select the control direction using the following values at the VAL input of the BSC_OFF block:

- 1 means step up
- 0 means step down

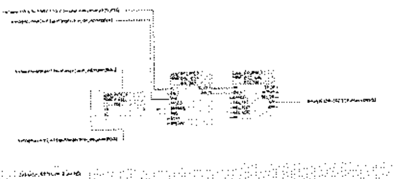


Figure 6-96 CFC Chart

Using this simple CFC chart, pressing the function keys to step up or down instantaneously can be displayed.

Motor Supervision Time

The runtime of the motor drive can be monitored from the device. This function is used to identify failures of the motor drive during switching and to trip actions, if necessary. To use the Motor supervision time, you must route the motor sliding contact (highest binary input) and set the proper motor runtime.

The motor sliding contact is active until the tap changer has reached the new position. This time is compared to the Motor supervision time. If the new tap position is not reached within the motor runtime, the Motor sup. time expired indication is set. The Trigger motor prot. sw. indication with which the motor can be switched off is output after 1.5 s.

Adjusting-Command Monitoring

The adjusting-command monitoring is used for checking the proper operation of the tap changer mechanism. The Tap changer function calculates the next logical tap position as a result of the higher/lower command. The time of position detection is determined as a function of the availability of the motor sliding contact. After resetting the active motor sliding contact, the Tap changer function reads the new tap position value. If the value for the next tap position could not be reached within the parameterized time Motor supervision time, the error message Position failure is issued.

The following position errors of the tap changer considered during this:

- Invalid tap position: The tap position is outside the predefined range of minimum value and maximum value
- Position command in the wrong direction (for example, if a higher tap was commanded and the tap changer responds with a lower position or vice versa)
- No operation of the tap changer (for example, if the tap-changer motor is defective or the position indication is not functioning)
- Illogical tap change operation (for example, if no logical tap position following the previous position is indicated)

The value on 0 during an unexpected interruption of the auxiliary voltage represents a special case. An invalid tap changer position without a corresponding adjusting command is signaled only as an invalid tap position in the Position failure table.

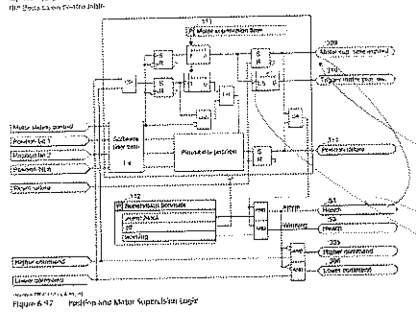


Figure 6-97 Position and Motor Supervision Logic

Supervision Behavior

Depending on the setting of the Supervision behavior parameter, the function reaches a health state of Alarm or Warning. You can set the Supervision behavior parameter to off, alarm block, or warning.

In the alarm block mode, the function is set to the health state Alarm. All tap-changer commands are blocked.

In the warning mode, the function is set to the health state Warning. Executing tap-changer commands is still possible.

You can reset the health state of alarm block or warning manually using the controllable Reset errors (Main menu → Device functions → Reset functions → Tap changer). As an alternative to this, you can also switch off the supervision function and then switch it on again.

Operating Meter

The device counts the number of successfully completed adjusting commands with the Op.ct. switching cycle metered value. The meter and memory levels are protected against an auxiliary-voltage failure. The switching cycle metered value can be preconfigured to 0 or to any other starting value.

You can access the statistical values via the operation panel on the device (measured values/statistics), via DIGSI, or using various communication protocols.

6.8.2 Application and Setting Notes

Parameters of the Transformer Tap Changer Function Group

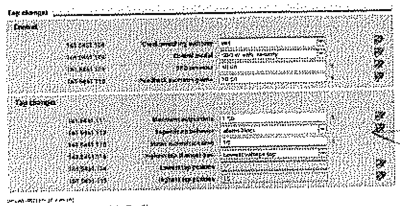


Figure 6-98 Parameters of the Tap Changer

NOTE

If run positions, this means internal tap-changer positions without voltage changes, are relevant, the following must be observed:

If these tap changer positions contain a suffix a and c or + and -, and additional switching pulses are not required, adjust the parameter for the feedback and motor supervision time to the actual motor runtime when passing through a run position. Siemens recommends parameterization with capturing the motor sliding contact.

Parameter: Check switching authority

- Default setting (_:104) Check switching authority = yes

Parameter: Control model

- Default setting (_:108) Control model = SBO w. enh. security

Use the Control model parameter to specify the control model according to IEC 61850 7-2. The following selection options are available:

- direct w. normal secur.
- SBO w. normal secur.
- direct w. enh. security
- SBO w. enh. security
- status only

Parameter: SBO time-out

- Default setting (_:109) SBO time-out = 30 s

With this setting, you specify the time for detecting the time-out of the SBO command. The range of values extends from 0.01 s to 1800.00 s. This is the time that can elapse between command acceptance and command execution (command model as per IEC 61850 7-2).

Parameter: Feedback monitoring time

- Default setting (_:110) Feedback monitoring time = 10 s

Reaching a new tap position after the switching command is monitored. If a new tap position is not reached, you specify with this setting the time when the command is canceled. The range of values extends from 0.01 s to 1800.00 s.

Parameter: Maximum output time

- Default setting (_:111) Maximum output time = 1.50 s

This parameter specifies the maximum output time. The range of values extends from 0.01 s to 1800.00 s. For activating motors to change the tap position, a time of 1.50 s is practical.

Parameter: Supervision behavior

- Default setting (_:112) Supervision behavior = alarm block

You can select whether the supervision is switched off (off) or if only a warning is indicated (warning). With the alarm block setting, an alarm indication is generated and the function is blocked.

Parameter: Motor supervision time

- Default setting (_:113) Motor supervision time = 10 s

After the motor supervision time has elapsed, the indication Motor sup. time expired is displayed. Additional information can be found in the margin title Motor Supervision Time, Page 368. The range of values extends from 5 s to 100 s.

Parameter: Highest tap changer pos.

- Default setting (_:116) Highest tap changer pos. = Lowest voltage tap

With the parameter Highest tap changer pos., indicate whether the lowest or highest voltage is present at the highest tap changer position.

Additional Settings (Properties Dialog Position)

Additional settings are assigned to the controllable Position. To display and adjust the settings, select Position in the DIGSI information matrix and select the Properties dialog. To do this, click the Properties tab.

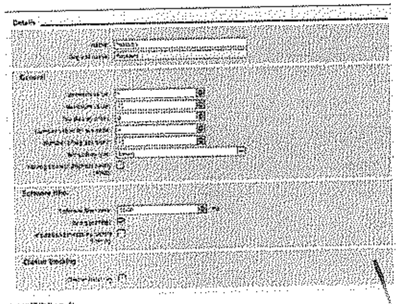


Figure 6-99 Properties Dialog

Parameter: Minimum value

- Default setting Minimum value = 1

Parameter: Maximum value

- Default setting Maximum value = 33

The Minimum value and Maximum value settings are initially calculated by DIGSI 5 based on the tap coding, the Number of tap positions, and the Tap-display offset. They represent the allowed control area of the position value. Positions outside this area are defined as invalid. This control area can be further restricted within the initially set physical range (see the Number of tap positions and the Tap-display offset).

Parameter: Tap-display offset

- Default setting Tap-display offset = 0

If you want to move the height of the displayed value in a positive or the negative direction with respect to the height of the actual value, enter the value for this in the Tap-display offset field.

Parameter: Number of bits f. tap code

- Default setting Number of bits f. tap code = 6

With the Number of bits f. tap code parameter, set the number of bits you need for coding the transformer taps. The number is dependent on the selected Encoding and on the Moving contact. For example, you need [illegible] bits for [illegible] binary-encoded transformer taps. The range of values extends from 2 to 32.

278

Parameter: Number of tap positions

- Default setting Number of tap positions = 15

With the Number of tap positions parameter, you set the number of transformer taps. The range of values extends from 2 to 127. The output of the tap position is limited from -63 to +63. If the number of taps is > 63, set the parameter Tap-display offset so that the tap position is within the range of -63 to +63.

Parameter: Tap-coding type

- Default setting Tap-coding type = binary

In the Tap-coding type list box, select the interpretation type of the indication pending at the binary input. You can select from the following options:

- binary
- 1-of-n
- BCD
- table
- BCD signed
- gray

If you want to specify an individual Tap-coding type, select table.

In the Representation of encoding section, select the numbering system in which your code table entries will take place alternatively.

- Binary (2 characters)
- Octal (8 characters)
- Decimal (10 characters)
- Hexadecimal (16 characters)

The selected option is valid for all inputs in the Encoding column.

If you change the number system and there are already entries in this column these will be converted to the new number system. The selection area becomes visible as soon as you have selected the setting table in the list box Tap-coding type.

NOTE

If the binary inputs used for encoding are all inactive, this indicates an invalid tap position (regardless of the display offset). For an invalid tap position, the display shows the position --- or -64 with quality invalid; the exception is BCD with sign, see Routing of the Binary Inputs (Tap Coding Type: BCD with Sign), page 174.

Enter the encoding for the tap in the Encoding column in the Code table. Enter the value according to the numbering system previously selected. Select the desired number of taps and number of bits for tap coding. Taps with the same encoding and taps with 0 coding are not permitted.

Routing of the Binary Inputs (Tap Coding Type: Binary)

The following table shows the routing of 3 binary inputs (BI 1 to BI 3) with 4 transformer tap positions designated 1 to 4. BI4 is the moving contact. The encoding is in binary.

Table 6-25 Routing of the Binary Inputs (Tap Coding Type: Binary)

	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X	X		
Meaning	Bit 1	Bit 2	Bit 3	Moving contact		
Tap = 1	1	0	0			

With 3 binary inputs, a maximum of $2^3 - 1 = 7$ tap positions can be mapped in binary code. If all routed binary inputs indicate 0, this is interpreted as a connection error and is reported by Position --- or -64 with quality invalid. The representation of transformer taps should start with the numerical value 1. The information properties must be configured as follows for the example.

Tap-coding type:	Binary
Number of tap positions:	4
Number of bits f. tap code:	4
Tap display offset:	0
Moving contact (highest binary input):	Yes

The 3 binary inputs must be numbered sequentially, for example, BI 1, BI 2, BI 3 and BI 4 for the moving contact.

Routing of the Binary Inputs (Tap Coding Type: BCD with Sign)

The following table shows the routing of 3 binary inputs (BI 1 to BI 3) with 7 transformer tap positions designated -3 to 3. The encoding uses BCD with sign.

Table 6-26 Routing of the Binary Inputs (Tap Coding Type: BCD with Sign)

	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X			
Meaning	Bit 1	Bit 2	Sign			
Tap = 3	1	1	1			

Using 3 binary inputs, a maximum of 7 tap positions can be mapped with the tap-coding type of BCD with sign. This yields the number of tap positions from -3 to 3. If all routed binary inputs indicate 0, this is recognized as tap 0. The 3 binary inputs must be numbered sequentially.

Tap-coding type:	BCD with sign
Number of tap positions:	7
Number of bits f. tap code:	3
Tap display offset:	0
Moving contact (highest binary input):	No

Routing the Tap Position to Binary Outputs

For the output of the adjusting commands, route the information step up and step down on one relay each, see following figure.

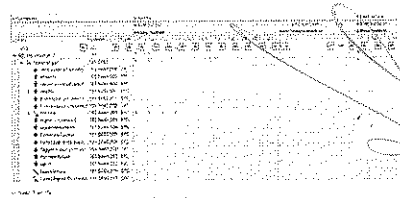


Figure 6-100 Routing the Tap Setting Commands

Parameter: Moving contact (highest binary input)

- Default setting Moving contact (highest binary input) = no

If the tap position is not to be recognized as valid and accepted until the motor sliding contact signals that it has reached the taps, then activate the Moving contact (highest binary input) option. If this parameter is set, the new positions are shown and labeled with an *.

Parameter: Software filter time

- Default setting Software filter time = 1000 ms

With this parameter, you specify the Software filter time for capturing the tap position. The range of values extends from 0 ms to 86400000 ms. Within this time, brief changes on the binary inputs are suppressed.

Parameter: Retrigger filter

- Default setting Retrigger filter = yes

With this parameter, you switch retriggering of the filtering time by a position change on or off.

Parameter: Indication timestamp before filtering

- Default setting Indication timestamp before filtering = no

With this parameter, you specify whether the hardware filtering time is accounted for in the time stamp of position capture.

Parameter: Chatter blocking

- Default setting Chatter blocking = no

With this parameter, you switch Chatter blocking on or off.

6.8.3 Settings (Properties Dialog)

The settings listed here can only be reached and changed by way of the Properties dialog of the Position Controllable.

Addr.	Parameter	C	Range of Values	Default Setting
General Information				
-	Minimum value		Calculated	-
-	Maximum value		Calculated	-
-	Tap-display offset		-63 to +63	0
-	Number of bits f. tap code		2 to 32	4
-	Number of tap positions		2 to 63	15
-	Tap-coding type		• binary • 1-of-n • BCD • table • BCD signed • gray	binary
Software filter				
-	Software filter time		0 ms to 86400000 ms	500 ms

6.8.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_:104	Tap changer:Check switching authority		• no • yes • advanced	yes
_:108	Tap changer:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:109	Tap changer:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:110	Tap changer:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Tap changer				
_:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.00 s
_:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:114	Tap changer:Lowest tap position		-64 to 64	1
_:115	Tap changer:Highest tap position		-64 to 64	15
Switching authority				
_:117	Tap changer:Swi.dev. related sw.auth.		• 0 • 1	false
_:118	Tap changer:Specific sw. authorities		• 0 • 1	true

Addr.	Parameter	C	Setting Options	Default Setting
_:119	Tap changer:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:120	Tap changer:Num. of specific sw.auth.		2 to 5	2
_:121	Tap changer:Multiple specific sw.auth.		• 0 • 1	false

6.8.5 Information List

No.	Information	Data Class (Type)	Type
Tap changer			
_:500	Tap changer:>Acquisition blocking	SPS	I
_:501	Tap changer:>Enable	SPS	I
_:502	Tap changer:Sw. authority local	SPS	I
_:503	Tap changer:Sw. authority remote	SPS	I
_:509	Tap changer:Sw. mode interlocked	SPS	I
_:510	Tap changer:Sw. mode non-interl.	SPS	I
_:504	Tap changer:>Reset AcqBlk&Subst	SPS	I
_:53	Tap changer:Health	ENS	O
_:301	Tap changer:End higher pos.reached	SPS	O
_:302	Tap changer:End lower pos.reached	SPS	O
_:305	Tap changer:Position	BSC	C
_:315	Tap changer:Higher command	SPS	O
_:306	Tap changer:Lower command	SPS	O
_:307	Tap changer:Command active	SPS	O
_:308	Tap changer:Motor sup. time expired	SPS	O
_:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:311	Tap changer:Position failure	SPS	O
_:312	Tap changer:Op.ct.	INS	O
_:313	Tap changer:Switching authority	ENS	O
_:314	Tap changer:Switching mode	ENS	O
_:319	Tap changer:Reset Latch	SPC	C
_:317	Tap changer:Switching auth. station	SPC	C
_:320	Tap changer:Enable sw. auth. 1	SPC	C
_:321	Tap changer:Enable sw. auth. 2	SPC	C
_:322	Tap changer:Enable sw. auth. 3	SPC	C
_:323	Tap changer:Enable sw. auth. 4	SPC	C
_:324	Tap changer:Enable sw. auth. 5	SPC	C

6.9 Voltage Controller

6.9.1 Overview of Functions

The transformer voltage controller functionality (ANSI 90V) is used to control power transformers (two-winding transformers, three-winding transformers, grid coupling transformers) and auto transformers using a motor-operated tap changer. The function provides automatic voltage control within a specified voltage range on the secondary side of the transformers or, as an alternative, at a remote load point (Z compensation or R/X compensation) in the network. In order to compensate for the voltage variations in the meshed system, use the LDC-Z procedure (Z compensation). For voltage drops on the line, use the LDC-X/R procedure (R/X compensation).

The control principle is based on the fact that a higher or lower command to the tap changer, as a function of the voltage change (ΔV) per tap, causes a voltage increase or decrease.

The voltage control operates on a tap-for-tap basis and compares the measured actual voltage (Vact) to the specified target voltage (Vtarget). If the voltage difference is greater than the set bandwidth (B), a higher or lower command is sent to the tap changer once the set time delay (T1) has elapsed. Specifying the time delay (T1) depends on the set controller response (inverse or linear), to avoid unnecessary adjusting commands during brief voltage deviations from the target value and for coordination with other automatic voltage controllers in the system.

The voltage controller function also monitors the currents on the upper-voltage side and the low-voltage side of the transformer to block the controller during impermissible operating states (overcurrent/undercurrent/undervoltage). The voltage controller function also has limiting values that, in special operating cases, suppress higher commands in the case of overvoltage and lower commands in the case of undervoltage.

6.9.2 Structure of the Function

The Two-winding transformer voltage controller, Three-winding transformer voltage controller, and Grid coupling transformer voltage controller function groups consist of 5 function blocks. Depending on the application, the function groups are preconfigured in the relevant application template by the manufacturer or can be copied into the corresponding device project during engineering.

The following figure shows, for example, the functional scope of the Two-winding transformer voltage controller function group.

Figure 6-101 Structure/Embedding of the Function Group

The functions General (SAFC), Tap changer (YLTC), and Voltage controller (ATCC) are logical nodes defined in IEC 61850-8-1.

The tap changer (YLTC) is the interface between the voltage controller (ATCC) and the motor-operated tap changer of the transformer (OLTC). This means that the voltage controller (ATCC) sends higher and lower commands to the tap changer. This tap changer issues command pulses to the motor-operated tap changer of the transformer (OLTC). The tap changer (YLTC) measures the tap positions and monitors the action of the motor-operated tap changer (OLTC).

The function group has interfaces to the following measuring points:

- Two-winding transformer:
  - Voltage, 3-phase
  - Current, 3-phase (optional)
- Three-winding transformer:
  - 2 x voltage, 3-phase
  - 2 x current, 3-phase (optional)
- Grid coupling transformer
  - 2 x 3-phase voltage
  - 2 x 3-phase current

Figure 6-102 shows these interfaces as a block structure.

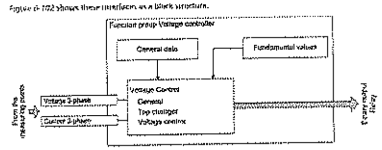


Figure 6-102 Structure of the Voltage Control Function Group

You can find the information and function measured values of the voltage controller in the DIGSI routing matrix.

6.9.3 Function Description

If the load is increased in an electricity-supply system, the voltage is reduced and vice versa. The power transformers are usually equipped with transformer tap changers (OLTC) so as to keep the power-system voltage at a constant level.

As a result, the transformer ratio is changed in predefined steps. Changing the transformer taps causes the voltage to change.

The Voltage control function is intended to control transformers with motor-operated transformer tap changers.

This function is designed to control the following:

- For two-winding transformers (2W): the voltage on the secondary circuit of the power transformer
- For three-winding transformers (3W): the voltage of the secondary winding 1 or winding 2
- For grid coupling transformers (GC): voltage of winding 1 or winding 2, selectively depending on the power direction

The control operation is based on a step-by-step principle. To move the tap changer one position higher or lower, a single control pulse is issued to the motor-drive mechanism of the tap changer. The length of the control pulse can be set over a large range so as to handle the very different types of tap-changer drives. The control pulse is issued if the measured voltage deviates from the set reference value by more than the preset voltage range for more than a given time period.

The voltage can be controlled at the voltage measuring point or at the load point in the electrical power system. In this case, the load point voltage is calculated on the basis of the measured load current and the known impedance between the voltage measuring point and the load point.

The following figures show possible configurations of the voltage controller for two-winding transformers with and without current measurement.

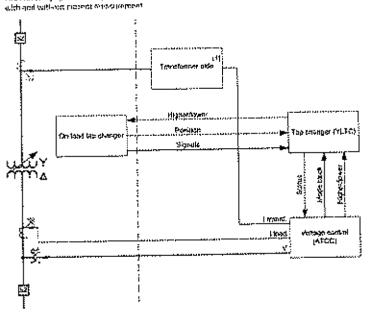


Figure 6-103 Voltage-Controller Constellation for Two-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

(1) Only if a transformer side is present

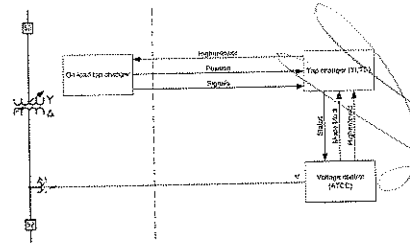


Figure 6-104 Voltage-Controller Constellation for Two-Winding Transformers without Current Measurement

Three-Winding Transformers

Three-winding transformers are special power transformers that have 2 separate windings on the secondary circuit and typically supply 2 different busbars. The voltage levels on the secondary circuit of the power transformer can either be the same or different. In addition to designs with 2 tap changers on the secondary circuits, in most cases, three-winding transformers are equipped with only one tap changer as on-load tap changer on the primary side. It is therefore necessary to feed both voltages of the secondary windings to the voltage measuring inputs (V1, V2) and to specify one of them, depending on the busbar situation, to the voltage controller as the control variable.

The voltages of side 1 and 2 of the three-winding transformer are simultaneously monitored. In the process, the voltage to be monitored can be automatically selected via the load current of both sides or by using one parameter. This parameter is the settings group switching via binary input, protocol or function keys. The uncontrolled voltage can be monitored in parallel to ensure that it remains within the defined voltage limits.

If a current measuring point is assigned to a function group, the voltage to be controlled can be automatically selected dependent on the load.

For automatic load change, the voltage of the transformer side into which the larger load current flows is controlled. The respective uncontrolled voltage is monitored for undervoltage and overvoltage.

In contrast to overvoltage on the controlled side, for overvoltage on the uncontrolled side, the higher impulse is blocked and no fast step down to a lower tap occurs. In case of undervoltage on the uncontrolled side, the lower commands are blocked if this behavior is activated for undervoltage supervision.

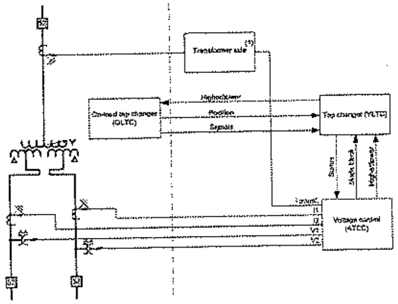


Figure 6-105 Voltage-Controller Constellation for Three-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

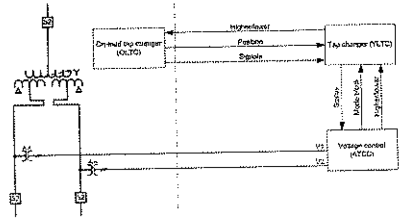


Figure 6-106 Voltage-Controller Constellation for Three-Winding Transformers without Current Measurement

Grid Coupling Transformers

Grid coupling transformers are special power transformers that connect 2 electrical power systems to one another. The load-side voltage is controlled. The power flow can change during operation. That is why both voltages and currents, winding 1 and winding 2, voltage measuring inputs (V1, V2) and current measuring inputs (I1 and I2) must be fed. A voltage must be specified as a function of the load situation to the voltage controller as the control variable.

The voltages of the windings 1 and 2 of the grid coupling transformers are simultaneously monitored. In the process, you can select the voltage to be controlled using one parameter. This parameter can be changed using the settings group switching via the binary input, protocol, or function keys.

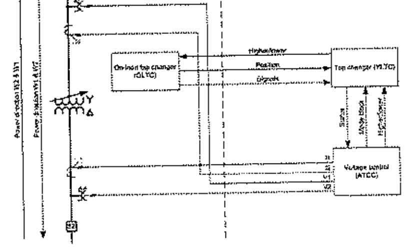


Figure 6-107 Voltage-Controller Constellation for Grid Coupling Transformers

On-Load Tap Changer

On-load tap changers are used to set the desired tap of a stepped winding of the transformer while under load. During switchover, the desired tap of the stepped winding is first selected by means of the tap selector. Next, the on-load tap changer switches over from the current-carrying tap to the selected tap. During this switchover, one tap of the stepped winding is briefly bridged by an ohmic resistor so that the load switchover takes place without power interruption. Physically, the tap changer is installed in the transformer tank or in a separate tank.

Tap Changer

The Tap changer function issues the adjusting commands to the on-load tap changer and receives the corresponding feedback. The function of the tap changer inside the voltage controller corresponds to that of the separate tap changer. The higher and lower tap commands are generated by the voltage controller. The Check switching authority, Control model, SBO time-out and Feedback monitoring time parameters are set only in the voltage controller.

You can find more information in chapter 6.9.4 Application and Setting Notes.

Voltage Controller

The Voltage controller function controls the voltage within the bandwidth and within the set voltage limits. Using the Mode parameter, you can turn the voltage controller on or off or set it for test mode.

With the parameter Number of target voltages, you can specify up to 4 target voltages. You can only activate one of these target voltages at a time using function key, communication, or a binary input. With the Set point mode active parameter, you can specify a valid target voltage via a communication network.

If the voltage controller is switched off, adjusting commands cannot be given to the tap changer in automatic operation or in manual operation. The set on-site or remote switching authority is independent of this.

You can set the controller operating mode via the Operating mode parameter or the Operating mode command to automatic operation or manual operation. In automatic operation, the voltage is controlled automatically in accordance with the set parameters.

Three-Winding Transformer Voltage Controller

For the two-winding transformer voltage controller, the measurands that are used to manage the feedback control are permanently defined.

With the three-winding transformer voltage controller, these measurands can be specified using one parameter (parameter Winding selection = Winding 1 or Winding 2) or they can be automatically selected (Winding selection = Via load current).

The winding is automatically selected by evaluating the load current in the windings. If the load current in one of the two windings is greater than the load current in the other winding by 5 % of the rated current for 10 s, then the winding voltage is controlled using the larger load current.

Grid Coupling Transformer Voltage Controller

For the two-winding transformer voltage controller, the measurands that are used to manage the feedback control are permanently defined.

With the grid coupling transformer voltage controller, these measurands can be selected using a parameter (parameter Winding selection = Winding 1 or Winding 2).

You can change the winding selection during operation using the settings group switching.

You can monitor the power flow direction. If the difference in the power of Winding 1 and Winding 2 is greater than 10 % of the rated power on the control side, the Power-flow revers. indication appears and the function switches to the alarm state.

280

Logic of the Function

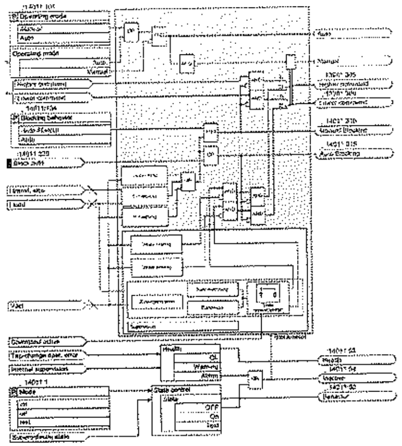


Figure 6-108 Higher-Level Logic of the Voltage Controller

(1) Manual operation
(2) Automatic operation
(3) Controllable
(4) Command

In accordance with the IEC 61850 standard. DO: LTCBlk: (Block automatic operation command). Automatic control can be blocked with a command.

The voltage controller measures the actual voltage (Vact) and compares it to the target voltage (Vtarget). If the difference between the measured voltage (control deviation D) is greater than the set bandwidth (B), a higher or lower command is sent to the tap changer once the set time delay (T1) has elapsed.

You can change the settings for control during operation with the settings group switching.

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 a substation automation technology (IEC 60870-5-103, IEC 61850)

You can find more information in chapter 3.?? Settings-Group Switching.

Control Deviation

The control deviation is calculated from the current actual voltage and the target voltage in relation to the rated voltage.

$$D = \frac{V_{act} - V_{target}}{V_{rated}} \cdot 100\,\%$$

D = Control deviation

Bandwidth

To minimize the number of switching operations by the tap changer, a permitted bandwidth is defined. If the actual voltage is within the bandwidth, no adjusting control commands are issued to the tap changer. If the actual voltage exceeds the defined bandwidth, an adjusting command is issued after the set time delay T1 delay. If the actual voltage returns to the voltage range of the bandwidth before T1 delay elapses, no adjusting control command is issued.

If the actual voltage returns to the voltage range of the bandwidth within the time delay T1, the running time delay T1 continues to count down, starting at the already elapsed time. If the actual voltage returns again to the set bandwidth while the time is counting down, the time delay T1 is started at the remaining time. In this way, the time delay is reduced in the event of frequent violations of the inner limit of the bandwidth.

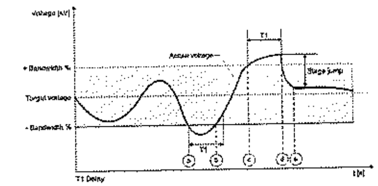


Figure 6-109 Actual Voltage Curve during Control Operation

(a) Actual voltage outside the bandwidth
(b) Actual voltage before T1 elapses within the bandwidth – no switching
(c) Actual voltage outside the bandwidth, T1 begins to elapse
(d) Actual voltage outside the bandwidth after T1, switching procedure initiated
(e) Switching procedure concluded, actual voltage within the bandwidth

Linear, Inverse Control Response

With linear control response, the controller reacts independently of the control deviation after the set time T1 delay. If more than one tap position change is required to bring the actual voltage back within the bandwidth, the set time T2 delay takes effect.

With inverse control response, the time T1 delay depends on the magnitude of the control deviation. Small deviations are tolerated for longer than larger ones. If the time delay is very small in accordance with the set characteristic curve, the time T1 Inverse Min takes effect.

The set inverse characteristic curve is a function of the parameter T1 delay. The characteristic curves arising for different settings of the time T1 delay are shown in chapter 6.?.4 Application and Setting Notes, under this Parameter: T1 characteristic.

Control Response with Zero Potential or Voltage Recovery

If the actual voltage is not within the defined bandwidth after a voltage recovery, it can be necessary for the voltage controller to send the 1st adjusting command with the T2 time. For this purpose, the parameter Regulate with T2 at start must be switched on.

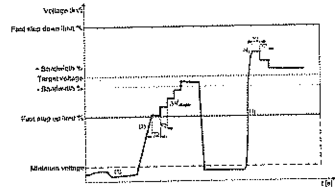


Figure 6-110 Actual Voltage Curve during Control with T2

(1) Actual voltage below the minimum voltage
(2) After switching on, the change to a higher tap occurs with time T2
(3) After the voltage recovery, the actual voltage is above the bandwidth
(4) Actual voltage outside the bandwidth. A fast step down is made with the time T2 until the bandwidth is reached.

Control Response in the Event of Larger Voltage Deviations

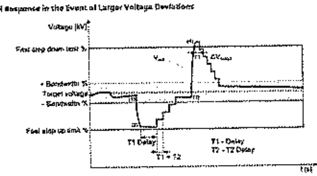


Figure 6-111 Actual Voltage Curve During Larger Control Deviations

(1) Actual voltage outside the bandwidth
(2) The change to a higher tap occurs after T1 and then T2
(3) Actual voltage inside the bandwidth
(4) Actual voltage outside the limit for a fast step down. A fast step down occurs until the bandwidth is reached

Fast Step Up Mode and Fast Step Down Mode

The fast step down mode and the fast step up mode allow a fast reaction to abnormal voltage situations. Figure 6-111 shows such a situation at point (4). A fast step down mode occurs until the bandwidth has been reached. The step time between 2 consecutive lower commands results from the following 2 conditions:

- The completion of a tap change command after the new valid position was detected
- The measurement time for capturing the new actual voltage

The activity of the fast step down mode and the fast step up mode is displayed with the indications (_:14011:308) Fast Step Down active and (_:14011:307) Fast Step Up active.

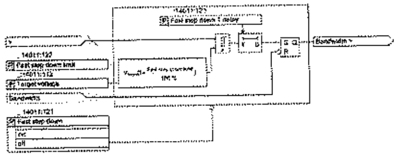


Figure 6-112 Logic of the Fast Step Down Mode

The fast step up mode operates in a similar fashion.

Function Supervision for Automatic Operation

If the actual voltage exceeds or falls below the set bandwidth for longer than the set time delay, this situation is shown by the indication (_:14011:309) Auto Monitor. If the actual voltage returns to the voltage range, the indication is reset. You can switch off the function monitor with a time delay = 0 min.

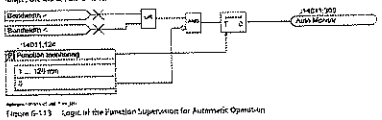


Figure 6-113 Logic of the Function Supervision for Automatic Operation

Phase Compensation

When using phase compensation, the voltage drop of a phase that is connected to a transformer can be included. In this case, 2 processes are available:

- Z compensation (LDC-Z)
- X and R compensation (LDC-XandR)

NOTE

The phase compensation is only active if power is flowing in the direction of the phase.

Z Compensation (LDC-Z)

Z compensation allows you to include the voltage drop of a line connected to the transformer. You can switch Z compensation on or off. If load is roughly constant, you can use Z compensation. Setting the parameters requires the calculation of the voltage increase (Target voltage rising) taking into consideration the load current (Max. load current).

The parameter Target voltage rising represents the voltage drop across the line as a % under rated load.

You can find more information and the calculation in chapter 6.9.4 Application and Setting Notes.

In case of active Z compensation, you must limit the maximum permitted voltage increase in relation to the target voltage to avoid a voltage at the transformer that is too high. To do this, set the parameter Max. Load current. In addition, the parameter Vmax threshold is active. If the actual voltage exceeds this threshold value, no more higher tap-change commands are issued.

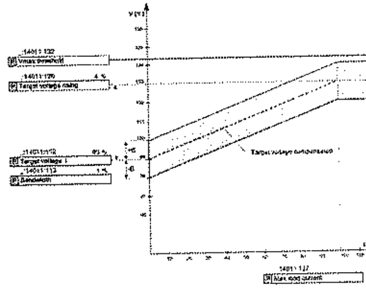


Figure 6-114 Control Characteristic with Z Compensation

X and R Compensation (LDC-XandR)

When using the X and R compensation, you need the phase data. With this data, it is possible to precisely compensate the voltage drop of the transmission lines. The following figure shows the effect of this compensation type.

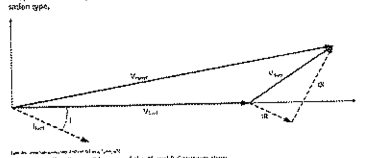


Figure 6-115 Phase Diagram of the X and R Compensation

You can also use the X and R compensation for the parallel control of transformers. If the X value is positive, the loss of voltage of the phase is compensated. If you are implementing parallel control with X and R compensation, then the X value is negative and considers the voltage increase from the busbar to the transformer.

V_{meas} Voltage on the transformer, voltage to be controlled

281

V_{Load} Voltage of load point (target voltage, $V_{Load} = V_{Target} - V_{drop}$)
V_{drop} Voltage drop of the phase
IR, IX Voltage drop through R and X of the power line
I_{Load} Load current
φ Load angle

If the X and R compensation is active, you must limit the maximum permitted voltage increase in relation to the target voltage to avoid a voltage at the transformer that is too high. To do this, set the parameter Vmax threshold. If the actual voltage exceeds this threshold value, no more higher tap change commands are issued.

Limiting Values

The limiting values cause no higher or lower adjusting commands to be given to the tap changer in the event of an upper limit violation (Vmax threshold) or lower limit violation (Vmin threshold). In this way, changing taps under abnormal voltage conditions and changing taps in the incorrect direction (for example, in the event of wiring errors) is prevented.

The lower and upper tap changer limits are included in the limiting values. The parameters Lower tap-position limit and Higher tap-position limit cause an additional restriction of the control range.

Blockings

The blockings prevent tap positions under abnormal network conditions. The following blocking functions are available:

- Undervoltage
- Overcurrent, load current
- Undercurrent
- External blocking (binary input)
- Blocking command LLN0 per IEC 61850
- Blocking in the event of pickup of the transformer differential protection

Using the parameter Blocking behavior, you specify whether the blockings are to take effect only in automatic operation (Auto) or in both automatic and manual operation (Auto+Manual).

Overcurrent blocking prevents tap changes in the event of an overload. For the current blockings, the positive-sequence system of the load current and of the current on the upper-voltage side of transformers is evaluated.

By assigning the tap changer to the transformer side, you also manage the current of the upper-voltage side. Perform this assignment in the appropriate Transformer side. Here, you must use the tap changer of the voltage controller.

Undervoltage blocking prevents tap changes in the event of a network collapse. The output signals of the voltage controller are blocked and, depending on the operating mode, the indication *Auto Blocking* and/or *Manual Blocking* is issued.

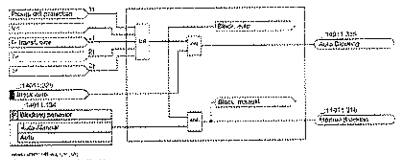


Figure 6-116 Logic Blockings

(1) If transformer differential protection is available
(2) If a current measurement is available

If the tap changer is assigned to the transformer side, if available, the current of the upper-voltage side is also monitored and the differential protection pickup blocks the voltage controller automatically.

Additional Blockings for the Three-Winding Transformer Voltage Controller

The blockings described in the above sections also apply to the controlled winding of the three-winding transformer. In addition, the blockings for undervoltage, minimum voltage, and overcurrent are used for the measurands of the uncontrolled side.

Additional Blockings for the Grid-Coupling Transformer Voltage Controller

For voltage control in grid coupling transformers, the voltages and currents of both windings are always used for the blockings.

Functional Measured Values

You can read the current status of the measured values for the two-winding, three-winding, and grid-coupling transformers at any time. The following 3 tables show you the available measured values.

Measured Values, Two-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
V act.	Current, measured positive-sequence voltage (referenced to phase-to-phase)	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load	Current measured load current (positive-sequence system)	A	A	Load current referenced to the rated current of the winding
V max	Maximum positive-sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Maximum voltage of the winding referenced to the rated voltage of the winding
V min	Minimum positive-sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding

Measured Value	Description	Primary	Secondary	% Referenced to
V target	Calculated target voltage with consideration of Z compensation	kV	V	Target voltage of the winding referenced to the rated voltage of the winding

The functional measured values V max and V min can be reset with the input indication >Reset min/max.

For the two-winding transformer, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control 2w → 90V V.contr. 2w
- Main menu → Measurements → Voltage control 2w → Statistics → 90V V.contr. 2w

Measured Values, Three-Winding Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact. w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact. w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to the rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to the rated voltage of winding 2
V tar. w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar. w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

The functional measured values Vmax 1, Vmax 2, Vmin 1 and Vmin 2 can be reset with the input indication >Reset min/max.

For the three-winding transformer, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control 3w → 90V V.contr. 3w
- Main menu → Measurements → Voltage control 3w → Statistics → 90V V.contr. 3w

Measured Values Grid Coupling Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact. w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact. w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to rated voltage of winding 2
V tar. w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar. w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

The functional measured values Vmax 1, Vmax 2, Vmin 1 and Vmin 2 can be reset with the input indication >Reset min/max.

For the grid coupling transformer, you can find the measured values under the following menu items of the device:

- Main menu → Measurements → Voltage control gc → 90V V.contr.gc
- Main menu → Measurements → Voltage control gc → Statistics → 90V V.contr.gc

Fundamental Values and Power Measured Values

The fundamental values and power measured values are always present in the Two-winding transformer voltage controller, Three-winding transformer voltage controller, and the Grid coupling transformer voltage controller function groups. Furthermore, you can find the fundamental values and power measured values for winding 1 and winding 2 in the Three-winding transformer voltage controller and in the Grid coupling transformer voltage controller function groups. These values cannot be deleted.

Table 6-27 and Table 6-28 show the total scope in case a 3-phase voltage measuring point is also connected.

Table 6-27 Possible Fundamental Values for the Voltage Controller Function Group

Fundamental Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	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_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3

Table 6-28 Possible Power Measured Values of the Voltage Controller Function Group

Power Measured Value		Primary	Secondary	% Referenced to
P_{total}	Active power (total power)	MW	W	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{total}	Reactive power (total power)	Mvar	Var	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	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

6.9.4 Application and Setting Notes

Two-Winding Transformer General

Parameter: Rated current

- Default setting (_:2311:101) Rated current = 1000.00 A

Parameter: Rated voltage

- Default setting (_:2311:102) Rated voltage = 400.00 kV

The measured values of the voltage controller can be displayed as primary values, secondary values, or in percent. With the Rated current and Rated voltage parameters, you set the reference value for the percentage values.

Three-Winding Transformer and Grid Coupling Transformer: General

Winding 1

Parameter: Rated current

- Default setting (_:2311:101) Rated current = 1000.00 A

Parameter: Rated voltage

- Default setting (_:2311:103) Rated voltage = 400.00 kV

Winding 2

Parameter: Rated current

- Default setting (_:2311:102) Rated current = 1000.00 A

Parameter: Rated voltage

- Default setting (_:2311:104) Rated voltage = 400.00 kV

The measured values of the voltage controller can be displayed as primary values, secondary values, or in percent. With the Rated current and Rated voltage parameters, you set the reference value for the percentage values.

Tap Changer

The parameters of the tap changer inside the voltage controller correspond to those of the tap changer in chapter 6.8.7 Application and Setting Notes.

For the tap changer inside the voltage controller, the parameters for the control model are copied from the voltage controller. This concerns the parameters:

- Checking the switching authority
- Control model
- SBO[1] Time out
- Feedback monitor.time

Voltage Controller

Parameter: Mode

- Default setting (_:14011:1) Mode = on

With the Mode parameter, you switch the voltage controller in on, off, or in test operation.

Parameter: Operating mode

- Default setting (_:14011:101) Operating mode = Manual

With the Operating mode parameter, you specify whether the controller is operating in Auto mode or in Manual.

Only Three-Winding Transformer

Parameter: Winding selection

- Default setting (_:15601:157) Winding selection = Winding 1

With the Winding selection parameter, you specify whether the controller controls the voltage of Winding 1 or Winding 2. With the Automatic setting, the voltage to be controlled is selected automatically as a function of the load current. You can switch to this method using the parameter Winding selection or the controllable *Automatic winding selection*.

If the controllable *Automatic winding selection* is set to Off or is not set, you can influence the winding to be controlled using the following 2 options:

- Via the Winding selection parameter
- Via the *Manual winding selection* controllable

The function value *Active winding* shows the winding selection.

Only Grid Coupling Transformer

Parameter: Winding selection

- Default setting (_:16351:161) Winding selection = Winding 1

With the Winding selection parameter, you specify whether the controller controls the voltage of Winding 1 or Winding 2.

You may select the winding to be controlled via the Winding selection parameter or the *Manual winding selection* controllable. The function value *Active winding* shows the winding selection.

[1] In the IEC 61850 standard, mentioned as Select before Operate (SBO)

282

Controlling

Parameter: Check switching authority

- Default setting (_:107) Check switching authority = yes

With the Check switching authority parameter, you specify whether the switching authority (On-site Remote) is checked during an adjusting command.

Parameter: Control model

- Default setting (_:109) Control model = SBO w. enh. security

This parameter Control model specifies the control model according to IEC 61850 7-2 that corresponds to the behavior of the data (SBO – Select before Operate).

You can select one of the following settings:

- direct w. normal secur.
- SBO w. normal secur.
- direct w. enh. security
- SBO w. enh. security

Parameter: SBO time-out

- Default setting (_:110) SBO time-out = 30.00 s

This parameter specifies the time for detecting the time-out of the SBO command. The range of values extends from 0.01 s to 1800.00 s. This is the time that can elapse between command acceptance and command execution (command model as per IEC 61850-7-2).

Parameter: Feedback monitoring time

- Default setting (_:111) Feedback monitoring time = 10.00 s

Reaching a new tap position after the adjusting command is monitored via the feedback monitoring time. If a new tap position is not reached, the command is canceled after this time.

Parameter: Set point mode active

- Default setting (_:14011:200) Set point mode active = on

With the parameter Set point mode active = on, you can send a target voltage to the controller via a communication network. The controller uses the specified voltage value as target voltage. If the controller does not receive any valid voltage values, it uses the original target voltage. You can switch the parameter on or off.

For the three-winding transformer, the address of the Set point mode active parameter is _:15601:171 while the address is _:16351:171 for the grid coupling transformer.

Only Two-Winding Transformer

Parameter: Number of target voltage

- Default setting (_:14011:156) Number of target voltage = 1

With this parameter, you specify the number of available target voltages (1 to 4). You can select a target voltage from the available ones using the function key, the communication, or a binary input.

NOTE

Keep in mind that the parameter Number of target voltage cannot be influenced by way of the settings group switching.

You can specify the target voltages (1 to 4) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1

- Default setting (_:14011:112) Target voltage 1 = 110.000 V

With the Target voltage 1 parameter, you specify the voltage that the controller is supposed to reach.

Parameter: Target voltage 2

- Default setting (_:14011:157) Target voltage 2 = 110.000 V

With the Target voltage 2 parameter, you specify the 2nd voltage that the controller is supposed to reach.

Parameter: Target voltage 3

- Default setting (_:14011:158) Target voltage 3 = 110.000 V

With the Target voltage 3 parameter, you specify the 3rd voltage that the controller is supposed to reach.

Parameter: Target voltage 4

- Default setting (_:14011:159) Target voltage 4 = 110.000 V

With the Target voltage 4 parameter, you specify the 4th voltage that the controller is supposed to reach.

Only Three-Winding Transformer

Parameter: Number of target voltage

- Default setting (_:15601:164) Number of target voltage = 1

With this parameter, you specify the number of available target voltages (1 W1/2 to 4 W1/2). You can select a target voltage from the available ones via the function key, the communication, or a binary input.

NOTE

Keep in mind that the parameter Number of target voltage cannot be influenced by way of the settings group switching.

You can specify the target voltages (1 W1/2 to 4 W1/2) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

- Default setting (_:15601:112) Target voltage 1 w1 = 110.000 V

Parameter: Target voltage 1 w2

- Default setting (_:15601:148) Target voltage 1 w2 = 110.000 V

Parameter: Target voltage 2 w1

- Default setting (_:15601:165) Target voltage 2 w1 = 110.000 V

Parameter: Target voltage 2 w2

- Default setting (_:15601:168) Target voltage 2 w2 = 110.000 V

Parameter: Target voltage 3 w1

- Default setting (_:15601:166) Target voltage 3 w1 = 110.000 V

Parameter: Target voltage 3 w2

- Default setting (_:15601:169) Target voltage 3 w2 = 110.000 V

Parameter: Target voltage 4 w1

- Default setting (_:15601:167) Target voltage 4 w1 = 110.000 V

Parameter: Target voltage 4 w2

- Default setting (_:15601:170) Target voltage 4 w2 = 110.000 V

Only Grid Coupling Transformer

Parameter: Number of target voltage

- Default setting (_:16351:164) Number of target voltage = 1

With this parameter, you specify the number of available target voltages (1 W1/2 to 4 W1/2). You can select a target voltage from the available ones via the function key, the communication, or a binary input.

NOTE

Keep in mind that the parameter Number of target voltage cannot be influenced by way of the settings group switching.

You can specify the target voltages (1 W1/2 to 4 W1/2) in primary, secondary, or in percent.

For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

- Default setting (_:16351:112) Target voltage 1 w1 = 110.000 V

Parameter: Target voltage 1 w2

- Default setting (_:16351:148) Target voltage 1 w2 = 110.000 V

Parameter: Target voltage 2 w1

- Default setting (_:16351:165) Target voltage 2 w1 = 110.000 V

Parameter: Target voltage 2 w2

- Default setting (_:16351:168) Target voltage 2 w2 = 110.000 V

Parameter: Target voltage 3 w1

- Default setting (_:16351:166) Target voltage 3 w1 = 110.000 V

Parameter: Target voltage 3 w2

- Default setting (_:16351:169) Target voltage 3 w2 = 110.000 V

Parameter: Target voltage 4 w1

- Default setting (_:16351:167) Target voltage 4 w1 = 110.000 V

Parameter: Target voltage 4 w2

- Default setting (_:16351:170) Target voltage 4 w2 = 110.000 V

Voltage Controller

Parameter: Bandwidth

- Default setting (_:113) Bandwidth = 1.0 %

With the Bandwidth parameter, you specify the voltage range where no control action higher or lower is to occur about the Target voltage 1. If the actual voltage is outside the bandwidth referenced to the Target voltage 1, a correction takes place.

Calculation of the Bandwidth:

NOTE

When calculating the Bandwidth B, keep the maximum accepted voltage deviation in the electrical power system and the tap voltage of the tap changer on the secondary side of the transformer in mind.

Calculation of the minimum bandwidth:

$$B[\%] \geq 0.6 \cdot \left(\frac{V_{sec,tap}}{V_{tapN}} - \frac{V_{sec,tap}}{V_{N-1,tap}}\right) \cdot V_{rated,sec} \cdot 100\,\% \cdot \frac{V_{max,prim}}{V_{rated,prim}}$$

$V_{rated,sec}$	Secondary rated voltage of the transformer
V_{tapN}	Primary tap voltage of the transformer of tap N
$V_{N-1,tap}$	Primary tap voltage of the transformer of tap N-1
$V_{max,prim}$	Maximum primary voltage of the transformer

Parameter: T1 characteristic

- Default setting (_:114) T1 characteristic = linear

Parameter: T1 delay

- Default setting (_:115) T1 delay = 40 s

You can adjust the control action so that the smallest number of adjusting commands possible is necessary. To do this, using T1 characteristic, you set the control response and, using T1 delay, you set a time delay.

In the Linear setting (linear control response), the control response is independent of the voltage deviation. A constant time delay applies here.

In the Inverse setting (inverse control response), the time delay is a function of the voltage deviation referenced to Target voltage 1. The greater the control deviation, the faster the control response. The control quality improves, but the switching frequency increases. The effective time delay results from:

$$t_{delay} = \frac{T_1 \cdot B}{|D|}$$

T_1 = Parameter T1 delay

$$D = \frac{V_{act} - V_{target}}{V_{rated}} \cdot 100\,\%$$

D = Control deviation

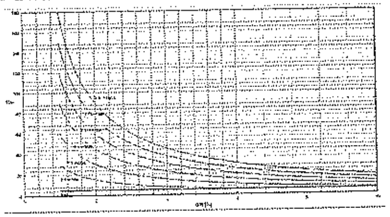


Figure 6-117 Inverse Control Characteristic

Parameter: T1 Inverse Min

- Default setting (_:116) T1 Inverse Min = 5 s

The T1 Inverse Min parameter is used to define the minimum time delay for the control action. This time applies only to the control response Inverse and the response cannot be shorter.

Parameter: T2 delay

- Default setting (_:117) T2 delay = 5 s

With the T2 delay parameter, you set the time the tap changer has to wait from one tap position to the next. During this time, several adjusting commands can be sent to the tap changer in one direction, which permits a correction of the actual voltage. The time delay T2 has an independent characteristic. The time T2 is generally set shorter than the time T1. If the time T2 is switched off by a setting equal to 0, the delay T1 is always active.

Parameter: Regulate with T2 at start

- Default setting (_:14011:155) Regulate with T2 at start = on

With the Regulate with T2 at start parameter, you can activate a shorter time than T1. This can be necessary for controlling a voltage recovery after switching on a transformer, if no voltage was available before. This setting controls with the shorter time T2 when starting the control action. You can switch this functionality on or off. If you always want to use the time T2 for control, you must set the Block T2 control.

For the three-winding transformer, the address of the Regulate with T2 at start parameter is _:15601:155 while the address is _:16351:155 for the grid coupling transformer.

Parameter: Fast step down

- Default setting (_:121) Fast step down = on

Parameter: Fast step down limit

- Default setting (_:122) Fast step down limit = 6.0 %

Parameter: Fast step down T delay

- Default setting (_:123) Fast step down T delay = 0.0 s

With this parameter, you can specify the time delay of the fast step down mode. If the actual voltage is greater than the value of the limit for the fast step down mode (_:122), the fast step-down mode is activated. If the voltage limit is exceeded for only a brief period within the time delay, a fast step down mode is not activated.

Parameter: Fast step up

- Default setting (_:118) Fast step up = off

Parameter: Fast step up limit

- Default setting (_:119) Fast step up limit = -6.0 %

Parameter: Fast step up T delay

- Default setting (_:170) Fast step up T delay = 2.0 s

With this parameter, you can specify the time delay of the fast step up mode. If the actual voltage is less than the value of the limit for the fast step up mode (_:119), the fast step up mode is activated. If the value drops below the voltage limit for only a brief period within the time delay, a fast step up mode is not activated.

Parameter: Function monitoring

- Default setting (_:174) Function monitoring = 15 min

You can delay the pickup of the function monitor. With the setting Function monitoring = 0 min, the function monitor is switched off.

Voltage Controller Only Grid Coupling Transformer

Parameter: Power flow supervision

- Default setting (_:16351:162) Power-flow supervision = on

With the Power-flow supervision parameter, you can monitor the power flow. You can switch the parameter on or off.

Line Compensation for the Two-Winding Transformer

Parameter: Line drop compensation

- Default setting (_:14011:126) Line drop compensation = off

You can use the Line drop compensation parameter to select the correction procedure of the load-dependent line voltage drop. There are 2 procedures available for selection: LDC-Z and LDC-X and R.

Consider the following parameters for Line drop compensation = LDC-Z :

Parameter: Target voltage rising

- Default setting (_:14011:126) Target voltage rising = 4.0 %

With the Target voltage rising parameter, you set the voltage drop across the line. The value represents the voltage increase in % of the Target voltage 1 that occurs at rated load. Only the magnitude of the current is considered. The set value is added to the Target voltage 1.

Target voltage rising [%] = ΔV_{rated} [%] if I_{load} = 100 %

$$\text{Target voltage rising [\%]} = (V_{LineEnd}[\%] - V_{Set}[\%]) \cdot \frac{100\,\%}{I_{load}[\%]}$$

$V_{LineEnd}$	Target voltage at the end of the line
V_{Set}	Target voltage
I_{load}	Load current in %

Parameter: Max load current

- Default setting (_:14011:127) Max load current = 100.0 %

With the setting of the parameter Max load current, you can prevent the voltage of the transformer from becoming too high in the event of extraordinarily high load current. If the load current exceeds the set value, no additional load-current compensation is calculated.

Consider the following parameter for Line drop compensation = LDC-X and R :

Parameter: R line

- Default setting (_:14011:153) R line = 0.0 Ω

With the R line parameter, you set the ohmic resistance of the power line.

Parameter: X line

- Default setting (_:14011:154) X line = 0.0 Ω

With the X line parameter, you set the reactance for the line to be protected.

In order to determine the voltage drop by the line, entering the parameter R line and X line is necessary for the procedure Line drop compensation = LDC-X and R. If the primary values are known and you would like to set the secondary values, use the following formula for the calculation:

$$X_{sec} = \frac{Ratio_{I}}{Ratio_{V}} \cdot X_{prim}$$

As an example, calculate X_{sec} with the following parameters:

Current transformer ratio	1000 A/1 A
Voltage transformer ratio	380 kV/0.1 kV
X_{prim}	21 Ω

Therefore, the result for X_{sec} is:

$$X_{sec} = \frac{1000\,A/1\,A}{380\,kV/0.1\,kV} \cdot 21\,\Omega = 5.53\,\Omega$$

If you are implementing a parallel control with the X and R compensation, then the X value is negative and considers the voltage increase from the busbar to the transformer.

Line Compensation for the Three-Winding Transformer and Grid Coupling Transformers

Parameter: Line drop compensation

283

- Default setting (_:125) Line drop compensation = off

Consider the following parameter for Line drop compensation = LDC-Z :

Parameter: Target voltage rising w1

- Default setting (_:126) Target voltage rising w1 = 4.0%

Parameter: Target voltage rising w2

- Default setting (_:147) Target voltage rising w2 = 4.0%

Parameter: Max load current

- Default setting (_:127) Max load current = 100.0 %

Consider the following parameter for Line drop compensation = LDC-R and X:

Parameter: R line w1

- Default setting (_:153) R line w1 = 0.0 Ω

Parameter: R line w2

- Default setting (_:155) R line w2 = 0.0 Ω

Parameter: X line w1

- Default setting (_:154) X line w1 = 0.0 Ω

Parameter: X line w2

- Default setting (_:156) X line w2 = 0.0 Ω

Limiting Values for the Two-Winding Transformer

Parameter: Lower tap-position limit

- Default setting (_:14011:102) Lower tap-position limit = 1

Parameter: Higher tap-position limit

- Default setting (_:14011:103) Higher tap-position limit = 2

With the parameters Lower tap-position limit and Higher tap-position limit, you can restrict the taps available in automatic operation. For example, using the parameter Higher tap-position limit, changes to higher taps to excessive ratios that would result in overvoltages in the event of a sudden loss of load are blocked.

Parameter: Vmin limiting

- Default setting (_:14011:128) Vmin limiting = on

Parameter: Vmin threshold

- Default setting (_:14011:129) Vmin threshold = 105.000 V

Parameter: Vmin time delay

- Default setting (_:14011:130) Vmin time delay = 10 s

Parameter: Vmax limiting

- Default setting (_:14011:131) Vmax limiting = on

Parameter: Vmax threshold

- Default setting (_:14011:132) Vmax threshold = 115.000 V

Parameter: Vmax time delay

- Default setting (_:14011:133) Vmax time delay = 10 s

The voltage limits are necessary only for special control situations. The overvoltage limit prevents a change to a higher tap by the controller if the limiting value Vmax threshold is exceeded. The undervoltage limit prevents a change to a lower tap by the controller if the voltage drops below the limiting value Vmin threshold.

Limiting Values for Three-Winding Transformers and Grid Coupling Transformers

Parameter: Vmin threshold w1

- Default setting (_:129) Vmin threshold w1 = 105.000 V

Parameter: Vmin threshold w2

- Default setting (_:148) Vmin threshold w2 = 105.000 V

Parameter: Vmax threshold w1

- Default setting (_:132) Vmax threshold w1 = 115.000 V

Parameter: Vmax threshold w2

- Default setting (_:149) Vmax threshold w2 = 115.000 V

Blockings for the Two-Winding Transformers

Parameter: Blocking behavior

- Default setting (_:14011:134) Blocking behavior = Auto-Manual

If the corresponding voltage limits are exceeded in either direction, the blockings prevent a change to a lower or higher tap. On the one hand, this prevents excessive wear of the contacts of the tap changer and, on the other hand, it prevents a system incident. With the parameter Blocking behavior, you set whether these blockings are effective only in automatic operation or in both automatic and manual operation.

Parameter: V< Blocking

- Default setting (_:14011:135) V< Blocking = on

Parameter: V< Threshold

- Default setting (_:14011:136) V< Threshold = 90.000 V

Parameter: V< Time delay

- Default setting (_:14011:137) V< Time delay = 0 s

Parameter: I> Blocking

- Default setting (_:14011:138) I> Blocking = on

Parameter: I> Threshold

- Default setting (_:14011:139) I> Threshold = 150 %

Parameter: I> Time delay

- Default setting (_:14011:140) I> Time delay = 0 s

If the load current exceeds the threshold value I> Threshold for the time I> Time delay, the overcurrent blocking prevents changing to a higher or lower tap. Set the threshold value I> Threshold in % in relation to the rated current. To do this, set the parameter I reference for % values.

Parameter: I< Blocking

- Default setting (_:14011:141) I< Blocking = off

Parameter: I< Threshold

- Default setting (_:14011:142) I< Threshold = 10 %

Parameter: I< Time delay

- Default setting (_:14011:143) I< Time delay = 10 s

If the load current drops below the threshold value I< Threshold for the time I< Time delay, the undercurrent blocking prevents changing to a higher or lower tap. Set the threshold value I< Threshold in % in relation to the rated current. To do this, set the parameter I reference for % values.

Blockings for Three-Winding Transformers and Grid Coupling Transformers

Parameter: V< Threshold w1

- Default setting (_:136) V< Threshold w1 = 90.000 V

Parameter: V< Threshold w2

- Default setting (_:150) V< Threshold w2 = 90.000 V

6.9.5 Settings

Two-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated 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
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:14011:1	90V V.contr.2w:Mode		• off • on • test	on
_:14011:101	90V V.contr.2w:Operating mode		• Manual • Auto	Manual
Control				
_:14011:107	90V V.contr.2w:Check switching authority		• no • yes	yes
_:14011:109	90V V.contr.2w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:14011:110	90V V.contr.2w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:14011:111	90V V.contr.2w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:14011:156	90V V.contr.2w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:14011:112	90V V.contr.2w:Target voltage 1		10.000 V to 340.000 V	110.000 V
_:14011:157	90V V.contr.2w:Target voltage 2		10.000 V to 340.000 V	110.000 V
_:14011:158	90V V.contr.2w:Target voltage 3		10.000 V to 340.000 V	110.000 V
_:14011:159	90V V.contr.2w:Target voltage 4		10.000 V to 340.000 V	110.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:113	90V V.contr.2w:Bandwidth		0.2 % to 10.0 %	1.0 %
_:14011:114	90V V.contr.2w:T1 characteristic		• Linear • Inverse	Linear
_:14011:115	90V V.contr.2w:T1 delay		5 s to 600 s	40 s
_:14011:116	90V V.contr.2w:T1 Inverse Min		5 s to 100 s	5 s
_:14011:117	90V V.contr.2w:T2 delay		0 s to 100 s	5 s
_:14011:118	90V V.contr.2w:Fast step up		• off • on	off
_:14011:119	90V V.contr.2w:Fast step up limit		-50.0 % to 0.0 %	6.0 %
_:14011:120	90V V.contr.2w:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_:14011:121	90V V.contr.2w:Fast step down		• off • on	on
_:14011:122	90V V.contr.2w:Fast step down limit		0.0 % to 50.0 %	6.0 %
_:14011:123	90V V.contr.2w:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_:14011:124	90V V.contr.2w:Function monitoring		0 min to 120 min	15 min
_:14011:155	90V V.contr.2w:Regulate with T2 at start		• off • on	on
_:14011:160	90V V.contr.2w:Set point mode active		• off • on	on
Line drop comp.				
_:14011:125	90V V.contr.2w:Line drop compensation		• off • LDC-Z • LDC-R and X	off
_:14011:126	90V V.contr.2w:Target voltage rising		0.0 % to 20.0 %	4.0 %
_:14011:127	90V V.contr.2w:Max load current		0.0 % to 500.0 %	100.0 %
_:14011:153	90V V.contr.2w:R line		0.0 Ω to 30.0 Ω	0.0 Ω
_:14011:154	90V V.contr.2w:X line		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_:14011:102	90V V.contr.2w:Lower tap-position limit		-128 to 127	1
_:14011:103	90V V.contr.2w:Higher tap-position limit		-128 to 127	15
_:14011:128	90V V.contr.2w:Vmin limiting		• off • on	on
_:14011:129	90V V.contr.2w:Vmin threshold		10.000 V to 340.000 V	105.000 V
_:14011:130	90V V.contr.2w:Vmin time delay		0 s to 20 s	10 s
_:14011:131	90V V.contr.2w:Vmax limiting		• off • on	on
_:14011:132	90V V.contr.2w:Vmax threshold		10.000 V to 340.000 V	115.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:133	90V V.contr.2w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:14011:134	90V V.contr.2w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:14011:135	90V V.contr.2w:V< blocking		• off • on	on
_:14011:136	90V V.contr.2w:V< Threshold		10.000 V to 340.000 V	90.000 V
_:14011:137	90V V.contr.2w:V< Time delay		0 s to 20 s	0 s
_:14011:138	90V V.contr.2w:I> blocking		• off • on	on
_:14011:139	90V V.contr.2w:I> Threshold		10 % to 500 %	150 %
_:14011:140	90V V.contr.2w:I> Time delay		0 s to 20 s	0 s
_:14011:141	90V V.contr.2w:I< blocking		• off • on	off
_:14011:142	90V V.contr.2w:I< Threshold		5 % to 100 %	10 %
_:14011:143	90V V.contr.2w:I< Time delay		0 s to 20 s	10 s

Three-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:103	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Winding 2				
_:2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:104	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
_:2311:106	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:15601:1	90V V.contr.3w:Mode		• off • on • test	on
_:15601:101	90V V.contr.3w:Operating mode		• Manual • Auto	Manual
_:15601:157	90V V.contr.3w:Winding selection		• Winding 1 • Winding 2 • WithMaxLoad	Winding 1
Control				
_:15601:107	90V V.contr.3w:Check switching authority		• no • yes	yes
_:15601:109	90V V.contr.3w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:15601:110	90V V.contr.3w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:15601:111	90V V.contr.3w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:15601:164	90V V.contr.3w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:15601:112	90V V.contr.3w:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_:15601:165	90V V.contr.3w:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_:15601:166	90V V.contr.3w:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_:15601:167	90V V.contr.3w:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_:15601:156	90V V.contr.3w:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_:15601:168	90V V.contr.3w:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_:15601:169	90V V.contr.3w:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_:15601:170	90V V.contr.3w:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V
_:15601:113	90V V.contr.3w:Bandwidth		0.2 % to 10.0 %	1.0 %
_:15601:114	90V V.contr.3w:T1 characteristic		• Linear • Inverse	Linear
_:15601:115	90V V.contr.3w:T1 delay		5 s to 600 s	40 s
_:15601:116	90V V.contr.3w:T1 Inverse Min		5 s to 100 s	5 s
_:15601:117	90V V.contr.3w:T2 delay		0 s to 100 s	5 s
_:15601:118	90V V.contr.3w:Fast step up		• off • on	off

284

Addr.	Parameter	C	Setting Options	Default Setting
_15601:119	90V V.contr.3w:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_15601:120	90V V.contr.3w:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_15601:121	90V V.contr.3w:Fast step down		• off • on	on
_15601:122	90V V.contr.3w:Fast step down limit		0.0 % to 50.0 %	6.0 %
_15601:123	90V V.contr.3w:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_15601:124	90V V.contr.3w:Function monitoring		0 min to 120 min	15 min
_15601:162	90V V.contr.3w:Power flow supervision		• off • on	on
_15601:163	90V V.contr.3w:Regulate with T2 at start		• off • on	on
_15601:171	90V V.contr.3w:Set point mode active		• off • on	on
Line drop comp.				
_15601:125	90V V.contr.3w:Line drop compensation		• off • LDC-Z • LDC-X and R	off
_15601:126	90V V.contr.3w:Target voltage rising w1		0.0 % to 20.0 %	4.0 %
_15601:147	90V V.contr.3w:Target voltage rising w2		0.0 % to 20.0 %	4.0 %
_15601:127	90V V.contr.3w:Max load current		0.0 % to 500.0 %	100.0 %
_15601:153	90V V.contr.3w:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_15601:154	90V V.contr.3w:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_15601:155	90V V.contr.3w:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_15601:156	90V V.contr.3w:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_15601:102	90V V.contr.3w:Lower tap-position limit		-128 to 127	1
_15601:103	90V V.contr.3w:Higher tap-position limit		-128 to 127	15
_15601:128	90V V.contr.3w:Vmin limiting		• off • on	on
_15601:129	90V V.contr.3w:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_15601:148	90V V.contr.3w:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_15601:130	90V V.contr.3w:Vmin time delay		0 s to 20 s	10 s
_15601:131	90V V.contr.3w:Vmax limiting		• off • on	on

Addr.	Parameter	C	Setting Options	Default Setting
_15601:132	90V V.contr.3w:Vmax threshold w1		10.000 V to 340.000 V	115.000 V
_15601:149	90V V.contr.3w:Vmax threshold w2		10.000 V to 340.000 V	115.000 V
_15601:133	90V V.contr.3w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_15601:134	90V V.contr.3w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_15601:135	90V V.contr.3w:V< Blocking		• off • on	on
_15601:136	90V V.contr.3w:V< Threshold w1		10.000 V to 340.000 V	90.000 V
_15601:150	90V V.contr.3w:V< Threshold w2		10.000 V to 340.000 V	90.000 V
_15601:137	90V V.contr.3w:V< Time delay		0 s to 20 s	0 s
_15601:138	90V V.contr.3w:I> Blocking		• off • on	on
_15601:139	90V V.contr.3w:I> Threshold		10 % to 500 %	150 %
_15601:140	90V V.contr.3w:I> Time delay		0 s to 20 s	0 s
_15601:141	90V V.contr.3w:I< Blocking		• off • on	off
_15601:142	90V V.contr.3w:I< Threshold		3 % to 100 %	10 %
_15601:143	90V V.contr.3w:I< Time delay		0 s to 20 s	10 s

Grid Coupling Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_2311:103	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Winding 2				
_2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_2311:104	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
_2311:106	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Tap changer				
_13981:111	Tap changer:Minimum output time		0.02 s to 1800.00 s	1.50 s
_13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap

Addr.	Parameter	C	Setting Options	Default Setting
_13981:114	Tap changer:Lowest tap position		-64 to 64	1
_13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_16351:1	90V V.contr.gc:Mode		• off • on • test	on
_16351:101	90V V.contr.gc:Operating mode		• Manual • Auto	Manual
_16351:161	90V V.contr.gc:Winding selection		• Winding 1 • Winding 2	Winding 1
Control				
_16351:107	90V V.contr.gc:Check switching authority		• no • yes	yes
_16351:109	90V V.contr.gc:Control model		• direct w. normal secur • SBO w. normal secur • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_16351:110	90V V.contr.gc:SBO time-out		0.01 s to 1800.00 s	30.00 s
_16351:111	90V V.contr.gc:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_16351:164	90V V.contr.gc:Number of target voltage		• 1 • 2 • 3 • 4	1
_16351:112	90V V.contr.gc:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_16351:165	90V V.contr.gc:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_16351:166	90V V.contr.gc:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_16351:167	90V V.contr.gc:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_16351:146	90V V.contr.gc:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_16351:168	90V V.contr.gc:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_16351:169	90V V.contr.gc:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_16351:170	90V V.contr.gc:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V
_16351:113	90V V.contr.gc:Bandwidth		0.2 % to 10.0 %	1.0 %
_16351:114	90V V.contr.gc:T1 characteristic		• Linear • Inverse	Linear
_16351:115	90V V.contr.gc:T1 delay		5 s to 600 s	40 s
_16351:116	90V V.contr.gc:T1 Inverse Min		5 s to 100 s	5 s
_16351:117	90V V.contr.gc:T2 delay		0 s to 100 s	5 s

Addr.	Parameter	C	Setting Options	Default Setting
_16351:118	90V V.contr.gc:Fast step up		• off • on	off
_16351:119	90V V.contr.gc:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_16351:120	90V V.contr.gc:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_16351:121	90V V.contr.gc:Fast step down		• off • on	on
_16351:122	90V V.contr.gc:Fast step down limit		0.0 % to 50.0 %	6.0 %
_16351:123	90V V.contr.gc:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_16351:124	90V V.contr.gc:Function monitoring		0 min to 120 min	15 min
_16351:162	90V V.contr.gc:Power-flow supervision		• off • on	on
_16351:163	90V V.contr.gc:Regulate with T2 at start		• off • on	on
_16351:171	90V V.contr.gc:Set point mode active		• off • on	on
Line drop comp.				
_16351:125	90V V.contr.gc:Line drop compensation		• off • LDC-Z • LDC-X and R	off
_16351:126	90V V.contr.gc:Target voltage rising w1		0.0 % to 20.0 %	4.0 %
_16351:147	90V V.contr.gc:Target voltage rising w2		0.0 % to 20.0 %	4.0 %
_16351:127	90V V.contr.gc:Max load current		0.0 % to 500.0 %	100.0 %
_16351:153	90V V.contr.gc:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_16351:154	90V V.contr.gc:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_16351:155	90V V.contr.gc:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_16351:156	90V V.contr.gc:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_16351:102	90V V.contr.gc:Lower tap-position limit		-128 to 127	1
_16351:103	90V V.contr.gc:Higher tap-position limit		-128 to 127	15
_16351:128	90V V.contr.gc:Vmin limiting		• off • on	on
_16351:129	90V V.contr.gc:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_16351:148	90V V.contr.gc:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_16351:130	90V V.contr.gc:Vmin time delay		0 s to 20 s	10 s
_16351:131	90V V.contr.gc:Vmax limiting		• off • on	on
_16351:132	90V V.contr.gc:Vmax threshold w1		10.000 V to 340.000 V	115.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_16351:149	90V V.contr.gc:Vmax threshold w2		10.000 V to 340.000 V	115.000 V
_16351:133	90V V.contr.gc:Vmax time delay		0 s to 20 s	10 s
Blocking				
_16351:134	90V V.contr.gc:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_16351:135	90V V.contr.gc:V< Blocking		• off • on	on
_16351:136	90V V.contr.gc:V< Threshold w1		10.000 V to 340.000 V	90.000 V
_16351:150	90V V.contr.gc:V< Threshold w2		10.000 V to 340.000 V	90.000 V
_16351:137	90V V.contr.gc:V< Time delay		0 s to 20 s	0 s
_16351:138	90V V.contr.gc:I> Blocking		• off • on	on
_16351:139	90V V.contr.gc:I> Threshold		10 % to 500 %	150 %
_16351:140	90V V.contr.gc:I> Time delay		0 s to 20 s	0 s
_16351:141	90V V.contr.gc:I< Blocking		• off • on	off
_16351:142	90V V.contr.gc:I< Threshold		3 % to 100 %	10 %
_16351:143	90V V.contr.gc:I< Time delay		0 s to 20 s	10 s

6.9.6 Information List

Two-Winding Transformer

No.	Information	Data Class (Type)	Type
General			
_2311:52	General:Behavior	ENS	O
_2311:53	General:Health	ENS	O
Tap changer			
_13981:500	Tap changer:>Acquisition blocking	SPS	I
_13981:501	Tap changer:>Enable	SPS	I
_13981:53	Tap changer:Health	ENS	O
_13981:301	Tap changer:End higher pos.reached	SPS	O
_13981:302	Tap changer:End lower pos.reached	SPS	O
_13981:308	Tap changer:Position	BALANCED SCORE CARD	C
_13981:305	Tap changer:Higher command	SPS	O
_13981:306	Tap changer:Lower command	SPS	O
_13981:307	Tap changer:Command active	SPS	O
_13981:309	Tap changer:Motor sup. time expired	SPS	O
_13981:310	Tap changer:Trigger motor prot. sw.	SPS	O

No.	Information	Data Class (Type)	Type
_13981:311	Tap changer:Position failure	SPS	O
_13981:312	Tap changer:Op.ct.	INS	O
_13981:317	Tap changer:Reset failure	SPC	C
90V V.contr. 2w			
_14011:81	90V V.contr.2w:>Block	SPS	I
_14011:85	90V V.contr.2w:>Reset min./max.	SPS	I
_14011:53	90V V.contr.2w:Health	ENS	O
_14011:54	90V V.contr.2w:Inactive	SPS	O
_14011:52	90V V.contr.2w:Behavior	ENS	O
_14011:301	90V V.contr.2w:End Higher pos. Auto	SPS	O
_14011:302	90V V.contr.2w:End Lower pos. Auto	SPS	O
_14011:326	90V V.contr.2w:Cmd. with feedback	BALANCED SCORE CARD	C
_14011:329	90V V.contr.2w:Block auto	SPC	C
_14011:332	90V V.contr.2w:Operating mode	SPC	C
_14011:305	90V V.contr.2w:Bandwidth >	SPS	O
_14011:306	90V V.contr.2w:Bandwidth <	SPS	O
_14011:307	90V V.contr.2w:Fast Step Up active	SPS	O
_14011:308	90V V.contr.2w:Fast Step Down active	SPS	O
_14011:309	90V V.contr.2w:Auto Monitor	SPS	O
_14011:310	90V V.contr.2w:Vmin Limiting	SPS	O
_14011:311	90V V.contr.2w:Vmax Limiting	SPS	O
_14011:315	90V V.contr.2w:Auto Blocking	SPS	O
_14011:316	90V V.contr.2w:Manual Blocking	SPS	O
_14011:317	90V V.contr.2w:V< Blocking	SPS	O
_14011:318	90V V.contr.2w:I> Blocking	SPS	O
_14011:319	90V V.contr.2w:I< Blocking	SPS	O
_14011:320	90V V.contr.2w:V act.	MV	O
_14011:321	90V V.contr.2w:dV act.	MV	O
_14011:322	90V V.contr.2w:I Load	MV	O
_14011:323	90V V.contr.2w:V max	MV	O
_14011:324	90V V.contr.2w:V min	MV	O
_14011:325	90V V.contr.2w:V target	MV	O
_14011:354	90V V.contr.2w:Target voltage 1	SPC	C
_14011:355	90V V.contr.2w:Target voltage 2	SPC	C
_14011:356	90V V.contr.2w:Target voltage 3	SPC	C
_14011:357	90V V.contr.2w:Target voltage 4	SPC	C
_14011:358	90V V.contr.2w:Set target voltage	APC	C
_14011:359	90V V.contr.2w:Block T1	SPC	C

Three-Winding Transformer

No.	Information	Data Class (Type)	Type
General			
_2311:52	General:Behavior	ENS	O
_2311:53	General:Health	ENS	O

285

No.	Information	Data Class (Type)	Type
Tap changer			
_:13981:500	Tap changer:>Regulation blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Dist.I.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.3w			
_:15601:81	90V V.contr.3w:>Block	SPS	I
_:15601:85	90V V.contr.3w:>Reset min.time	SPS	I
_:15601:53	90V V.contr.3w:Health	ENS	O
_:15601:54	90V V.contr.3w:Inactive	SPS	O
_:15601:57	90V V.contr.3w:Behavior	ENS	O
_:15601:301	90V V.contr.3w:End Higher pos. Auto	SPS	O
_:15601:302	90V V.contr.3w:End Lower pos. Auto	SPS	O
_:15601:332	90V V.contr.3w:Cmd. with feedback	BALANCED SCORECARD	C
_:15601:335	90V V.contr.3w:Block auto	SPC	C
_:15601:336	90V V.contr.3w:Operating mode	SPC	C
_:15601:305	90V V.contr.3w:Bandwidth >	SPS	O
_:15601:306	90V V.contr.3w:Bandwidth <	SPS	O
_:15601:307	90V V.contr.3w:Fast Step Up active	SPS	O
_:15601:308	90V V.contr.3w:Fast Step Down active	SPS	O
_:15601:309	90V V.contr.3w:Auto Monitor	SPS	O
_:15601:357	90V V.contr.3w:Power-flow superv.	SPS	O
_:15601:310	90V V.contr.3w:Vmin Limiting w1	SPS	O
_:15601:311	90V V.contr.3w:Vmin Limiting w2	SPS	O
_:15601:312	90V V.contr.3w:Vmax Limiting w1	SPS	O
_:15601:313	90V V.contr.3w:Vmax Limiting w2	SPS	O
_:15601:314	90V V.contr.3w:Auto Blocking	SPS	O
_:15601:315	90V V.contr.3w:Manual Blocking	SPS	O
_:15601:316	90V V.contr.3w:V< Blocking w1	SPS	O
_:15601:317	90V V.contr.3w:V< Blocking w2	SPS	O
_:15601:318	90V V.contr.3w:I> Blocking	SPS	O
_:15601:319	90V V.contr.3w:I< Blocking	SPS	O
_:15601:320	90V V.contr.3w:Vact w1	MV	O
_:15601:321	90V V.contr.3w:Vact w2	MV	O

No.	Information	Data Class (Type)	Type
_:15601:322	90V V.contr.3w:Vact w3	MV	O
_:15601:323	90V V.contr.3w:I load w1	MV	O
_:15601:324	90V V.contr.3w:I load w2	MV	O
_:15601:325	90V V.contr.3w:Vmax 1	MV	O
_:15601:326	90V V.contr.3w:Vmax 2	MV	O
_:15601:327	90V V.contr.3w:Vmin 1	MV	O
_:15601:328	90V V.contr.3w:Vmin 2	MV	O
_:15601:329	90V V.contr.3w:V set w1	MV	O
_:15601:330	90V V.contr.3w:V set w2	MV	O
_:15601:358	90V V.contr.3w:Target voltage 1 w1	SPC	C
_:15601:359	90V V.contr.3w:Target voltage 2 w1	SPC	C
_:15601:360	90V V.contr.3w:Target voltage 3 w1	SPC	C
_:15601:361	90V V.contr.3w:Target voltage 4 w1	SPC	C
_:15601:362	90V V.contr.3w:Target voltage 1 w2	SPC	C
_:15601:363	90V V.contr.3w:Target voltage 2 w2	SPC	C
_:15601:364	90V V.contr.3w:Target voltage 3 w2	SPC	C
_:15601:365	90V V.contr.3w:Target voltage 4 w2	SPC	C
_:15601:366	90V V.contr.3w:Set target voltage w1	APC	C
_:15601:367	90V V.contr.3w:Set target voltage w2	APC	C
_:15601:368	90V V.contr.3w:Block T1	SPC	C
_:15601:356	90V V.contr.3w:Winding act.	INS	O
_:15601:369	90V V.contr.3w:Winding selec. manual	SPC	C
_:15601:370	90V V.contr.3w:Winding selec. auto	SPC	C

Grid Coupling Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Regulation blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:308	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Dist.I.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C

No.	Information	Data Class (Type)	Type
90V V.contr.gc			
_:16351:81	90V V.contr.gc:>Block	SPS	I
_:16351:85	90V V.contr.gc:>Reset min.time	SPS	I
_:16351:53	90V V.contr.gc:Health	ENS	O
_:16351:54	90V V.contr.gc:Inactive	SPS	O
_:16351:57	90V V.contr.gc:Behavior	ENS	O
_:16351:301	90V V.contr.gc:End Higher pos. Auto	SPS	O
_:16351:302	90V V.contr.gc:End Lower pos. Auto	SPS	O
_:16351:332	90V V.contr.gc:Cmd. with feedback	BALANCED SCORECARD	C
_:16351:335	90V V.contr.gc:Block auto	SPC	C
_:16351:336	90V V.contr.gc:Operating mode	SPC	C
_:16351:305	90V V.contr.gc:Bandwidth >	SPS	O
_:16351:306	90V V.contr.gc:Bandwidth <	SPS	O
_:16351:307	90V V.contr.gc:Fast Step Up active	SPS	O
_:16351:308	90V V.contr.gc:Fast Step Down active	SPS	O
_:16351:309	90V V.contr.gc:Auto Monitor	SPS	O
_:16351:357	90V V.contr.gc:Power-flow superv.	SPS	O
_:16351:310	90V V.contr.gc:Vmin Limiting w1	SPS	O
_:16351:311	90V V.contr.gc:Vmin Limiting w2	SPS	O
_:16351:312	90V V.contr.gc:Vmax Limiting w1	SPS	O
_:16351:313	90V V.contr.gc:Vmax Limiting w2	SPS	O
_:16351:314	90V V.contr.gc:Auto Blocking	SPS	O
_:16351:315	90V V.contr.gc:Manual Blocking	SPS	O
_:16351:316	90V V.contr.gc:V< Blocking w1	SPS	O
_:16351:317	90V V.contr.gc:V< Blocking w2	SPS	O
_:16351:318	90V V.contr.gc:I> Blocking	SPS	O
_:16351:319	90V V.contr.gc:I< Blocking	SPS	O
_:16351:320	90V V.contr.gc:Vact w1	MV	O
_:16351:321	90V V.contr.gc:Vact w2	MV	O
_:16351:322	90V V.contr.gc:ΔV act.	MV	O
_:16351:323	90V V.contr.gc:I load w1	MV	O
_:16351:324	90V V.contr.gc:I load w2	MV	O
_:16351:325	90V V.contr.gc:Vmax 1	MV	O
_:16351:326	90V V.contr.gc:Vmax 2	MV	O
_:16351:327	90V V.contr.gc:Vmin 1	MV	O
_:16351:328	90V V.contr.gc:Vmin 2	MV	O
_:16351:329	90V V.contr.gc:V set w1	MV	O
_:16351:330	90V V.contr.gc:V set w2	MV	O
_:16351:358	90V V.contr.gc:Target voltage 1 w1	SPC	C
_:16351:359	90V V.contr.gc:Target voltage 2 w1	SPC	C
_:16351:360	90V V.contr.gc:Target voltage 3 w1	SPC	C
_:16351:361	90V V.contr.gc:Target voltage 4 w1	SPC	C
_:16351:362	90V V.contr.gc:Target voltage 1 w2	SPC	C
_:16351:363	90V V.contr.gc:Target voltage 2 w2	SPC	C
_:16351:364	90V V.contr.gc:Target voltage 3 w2	SPC	C

No.	Information	Data Class (Type)	Type
_:16351:365	90V V.contr.gc:Target voltage 4 w2	SPC	C
_:16351:366	90V V.contr.gc:Set target voltage w1	APC	C
_:16351:367	90V V.contr.gc:Set target voltage w2	APC	C
_:16351:368	90V V.contr.gc:Block T1	SPC	C
_:16351:356	90V V.contr.gc:Winding act.	INS	O
_:16351:369	90V V.contr.gc:Winding selec. manual	SPC	C
_:16351:370	90V V.contr.gc:Winding selec. auto	SPC	C

7 Protection and Automation Functions

7.1 Inherent Circuit-Breaker Failure Protection

7.1.1 Overview of Functions

The Circuit-breaker failure protection function (ANSI 50BF) monitors the tripping of the associated circuit-breaker (CB) and generates a backup trip signal if the circuit-breaker fails.

7.1.2 Structure of the Function

The function Circuit-breaker failure protection (CBFP) can be used in the Circuit-breaker function group.

Function group	Circuit breaker
Function	Circuit-breaker failure protection (CBFP)

Figure 7-1 Structure/Embedding of the Function

Figure 7-2 shows the functionalities and the function control of the function.

The start is initiated by the device-internal protection function or by an external protection. Along with the start, the current flow criterion or the circuit-breaker auxiliary contact criterion is used to check whether the circuit breaker is closed. If the circuit breaker is closed, the function picks up and starts the time delay. During the time delay, the system checks continuously whether the circuit breaker has opened. If this is the case, the function drops out. If the circuit breaker is not opened, the function trips upon expiration of the time delay.

The following description elaborates on the detailed functionality of the individual function blocks.

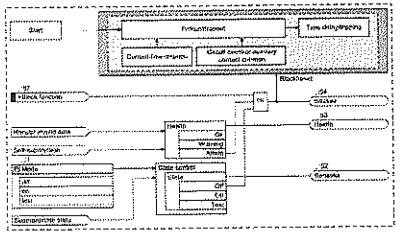


Figure 7-2 Function Logic Overview

286

7.1.3 Function Description

The Circuit-breaker failure protection function is started by device-internal protection functions and/or externally (via a binary input or an interface, such as GOOSE). Figure 7-3 and Figure 7-4 show the functionality.

Internal Start

By default, every device-internal protection stage, which is to control the local circuit breaker, starts the circuit-breaker failure protection. The function is started by the tripping of the protection stage. In the default setting, the starting signal (Internal start (see Figure 7-3)) is held when the pickup signal has a falling edge or the protection function has tripped. The Circuit-breaker failure protection function drops in this case only dropout if the circuit breaker is detected to be open. This is detected using the current flow or circuit-breaker auxiliary contact criterion. If necessary, the Circuit-breaker failure protection function can also drop out when the pickup signal has a falling edge or the protection function trips (internal starting signal is not held).

Using routing, you can specify whether individual protection stages or protection functions are to be used as the starting source or whether starting happens only externally.

The internal starting sources are routed in the protection function groups via the **Circuit-breaker interaction** entry (for this, see 2.1 Function Embedding in the Device).

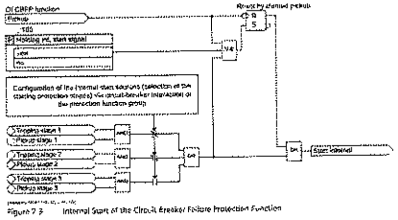


Figure 7-3 Internal Start of the Circuit-Breaker Failure Protection Function

External Start

The parameter Start via binary input is used to set whether the external start is initiated by a 1-channel or 2-channel signal. The required routing of the input signals is compared with the setting. If a routing is missing, an error message is generated. The Health signal changes to the state Warning.

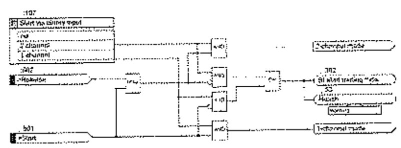


Figure 7-4 Configuration of the External Start of the Circuit-Breaker Failure Protection Function

In 1-channel operation, the start is initiated with the binary input signal >Start only.

In 2-channel operation, the binary input signal >Release must also be activated to initiate the start. In the default setting, the starting signal External start drops out immediately when the input signals have a falling edge (see Figure 7-5). If necessary, the starting signal can be held. In this case the start remains active when the binary input signals have a falling edge.

The input signals are monitored to avoid an unwanted pickup of the function.

If either of the signals >Start or >Release is active for more than the set time without the function picking up, an error in the binary input circuit is assumed. The corresponding signal is blocked to exclude an external pickup of the function. An indication to this effect is output, and the Health signal changes to the state Warning. The blocking is reset as soon as the binary input signal drops out.

Supervision is disabled in the following cases:

- On pickup of the Circuit-breaker failure protection function (only in the case of an external start). This prevents an unwanted pickup of the supervision if the external protection that starts the Circuit-breaker failure protection function uses a lockout functionality. When the starting signal drops out, the supervision is active again.
- As long as the function or the device is in test mode. This allows to check the function without the supervision blocking the function.

If the >Start signal is active but no release signal is present after the settable supervision time expires, the pickup is blocked and an indication to this effect is output. The Health signal changes to the state Warning. The blocking is reset with the dropout of the starting signal.

The binary input signals only take effect if the binary inputs are activated for at least 10 ms (SW filter, see Figure 7-5).

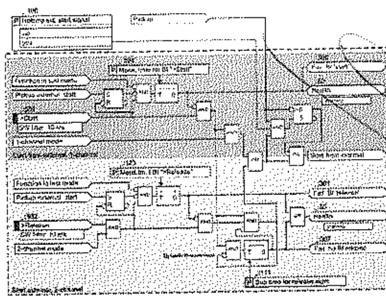


Figure 7-5 External Start of the Circuit-Breaker Failure Protection Function, Logic

Current-Flow Criterion

The current-flow criterion is the primary criterion for determining the circuit-breaker position. A circuit-breaker pole is supposed to be closed, and the current-flow criterion fulfilled, as soon as one of the phase currents exceeds the phase-current threshold value, and at the same time a plausibility current exceeds the associated threshold value. The plausibility current can be either a 2nd phase current (to compare with the threshold value for phase currents) or the zero-sequence or negative-sequence current (to compare with the sensitive threshold value). The additional evaluation of the plausibility current increases the safety of the criterion.

In the case of ground faults, the sensitive threshold value can be dynamically applied to the phase currents as well. The current-flow criterion is fulfilled when the currents exceed the sensitive threshold value. The phase-current threshold value is then ineffective. The binary signal >Threshold sensitive is used for the switch over.

If you set the 3I0 criterion parameter to Direct release, you prevent the plausibility check of the zero-sequence current. In this way, a pickup only by way of the current can be achieved. Using the Threshold 3I0 dir. release parameter, you set the threshold value to be exceeded.

If you set the I2 criterion parameter to Direct release, you also switch off the plausibility check of the negative-sequence current. Using the Threshold I2 dir. release parameter, you set the threshold value to be exceeded.

If you set the I2 criterion parameter to Direct release, a plausibility check is performed via the phase currents with 1/3 * Threshold I2 dir. release.

The measuring algorithm is optimized for fast dropout when the value drops below the threshold value.

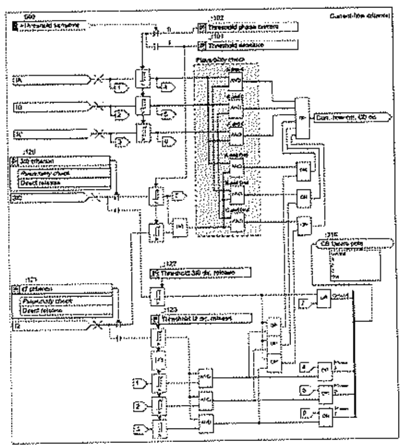


Figure 7-6 Current-Flow Criterion

Circuit-Breaker Auxiliary-Contact Criterion

Settings allow you to specify whether the circuit breaker auxiliary contacts are permitted for determining the circuit-breaker position.

The double-point indication 3-pole position (from the Circuit-breaker function block) is used to determine whether all 3 poles of the circuit breaker are closed. If the double-point indication is not routed, the output is an error message. Furthermore, the Health signal changes to the state Warning.

The detection of a state disturbed position (not an intermediate position) has the effect that the circuit-breaker auxiliary-contact criterion is not used (the internal signal Aux. con. crit.: CB closed is disabled).

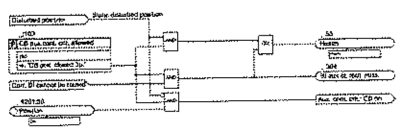


Figure 7-7 Circuit-Breaker Auxiliary-Contact Criterion

Pickup/Dropout

After the start, a check is performed whether the circuit breaker is closed. The current-flow criterion and the circuit-breaker auxiliary-contact criterion are available for this purpose.

Even if the circuit-breaker auxiliary contact criterion is permitted, preference is given to the fulfilled current-flow criterion because the current-flow criterion is the most reliable criterion for detecting whether the circuit breaker is closed. This means that the circuit breaker is deemed to be closed if it is closed according to the current-flow criterion but at the same time open according to the circuit-breaker auxiliary-contact criterion.

If no current is flowing at the start time, the function can only pick up on the basis of the circuit-breaker auxiliary-contact criterion. For this purpose, the circuit-breaker auxiliary contacts must be permitted as criterion. When the current begins to flow after the start, the function switches over to the current-flow criterion.

If the circuit breaker is detected to be closed, the function picks up.

The pickup starts a time delay (see Delay/Tripping). While the delay is running, the system checks continuously whether the circuit breaker has opened. In the default setting, the opening of the circuit breaker is checked on the basis of the currently valid criterion, which is normally the current-flow criterion because it is preferred. If until expiration of the time delay, no current flow above the set threshold values has been detected, the circuit-breaker auxiliary-contact criterion becomes effective.

The function has also a setting in which dropout is only possible if both criteria in parallel detect the circuit breaker to be open (dropout with auxiliary contact and current-flow criterion).

In the default setting, the internal starting signal is held (see Figure 7-3 and Figure 7-5). This means that dropout is controlled solely by the switch or the circuit-breaker auxiliary-contact criterion. If dropout is also to occur on the falling edge of the starting signal (that is, when the pickup signal has a falling edge or the protection function trips), holding of the start signal must be disabled.

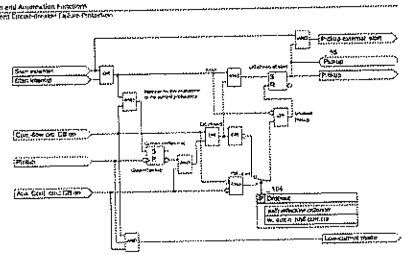


Figure 7-8 Pickup/Dropout of the Circuit-Breaker Failure Protection Function

Delay/Tripping

In a first step, tripping at the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. If the local CB was not yet tripped, for example, in the event of an external start of the circuit-breaker failure protection, the trip logic of the circuit breaker itself is activated when the time delay T1 elapses.

Time delay T2 (backup tripping) can commence in parallel either with the start of time T1 or after expiration of time T1.

If time delay T2 expires without a dropout of the function, a circuit-breaker failure is assumed and the backup tripping signal Tripping T2 is output. If there is a protection interface in the device, if needed a transfer-trip signal can be sent to the opposite end.

You can find detailed information in the chapter 3.5.7 Protection Interface and Protection Topology.

If the >CB defect input signal is valid, any expiration of the T1 signal is suppressed, and the backup tripping signal T2 is generated immediately (without delay). The binary input of the >CB defect input signal must be activated for at least 20 ms before the signal becomes valid.

With help of the CB failure pole indication, you can determine the phase currents that are above the threshold value at the tripping time T2.

The Minimum operate time parameter defines the minimum duration for tripping the function. In contrast to other protection functions, the parameter is set within its own function. As a result, the setting is independent of the identically named global parameter that is set in the Device settings.

287

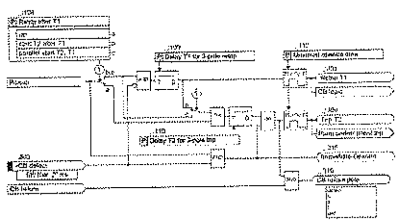


Figure 7-9 Delay/Tripping of the Circuit-Breaker Failure Protection Function

7.1.4 Application and Setting Notes

Figure 7-10 gives an overview of the functions involved in an external start of the CBFP function. In the case of an internal start, there is no external protection device and the protection functionality is located in the CBFP device.

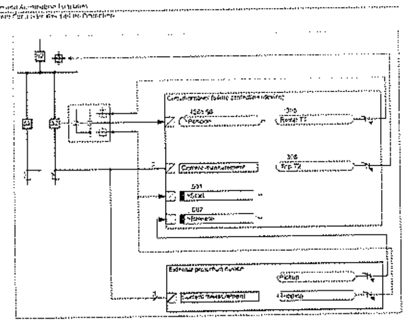


Figure 7-10 Circuit Breaker Failure Protection with External Start, Tripping Repetition and 3-Pole Tripping (T2)

Routing: Configuration of Internal Starting Sources (Internal Protection Function)

Configuration of the internal starting sources takes place in the protection function groups via the Circuit-breaker interaction entry (for this, see 2.1 Function Embedding in the Device).

By default, the function can be started by any tripping of the internal protection functions, which control the local circuit breaker. Depending on the specific application, it can be necessary to exclude certain device-internal protection functions from starting the CBFP. For instance, busbar disconnection following a local circuit-breaker failure can be undesirable in the case of load shedding applications or ground faults in isolated/resonant-grounded systems.

Where a start exclusively from external sources is required, all internal protection functions must be routed so that they are excluded as a starting source.

Parameter: Start via binary input

- Default setting (_:107) Start via binary input = no

Parameter Value	Description
no	If no external start is intended, the parameter is set to no.

Parameter Value	Description
2-channel	2-channel start is used if there is a risk that the circuit-breaker failure protection causes a tripping due to a faulty activation of the start binary input. This is the case in the following situations: a) The CBFP pickup value (threshold value) is set to less than the load current. b) There can be operating conditions under which the current flow is higher than the pickup value. To avoid a possible overfunction, Siemens recommends using the 2-channel start.
1-channel	The 1-channel start must be used where only one control circuit of a binary input is available for starting the CBFP.

Input Signals: >Start, >Release

The start and release input signals have a filtering time of 20 ms as default setting. If a transient control signal to the binary inputs is to be expected due to the design of the external binary input control circuits and due to environmental conditions, the filtering time can be extended. This delays the start of the CBFP function.

Input Signals	Description
>Start	The start input signal is linked with the tripping of the external protection device (see Figure 7-10).
>Release	The enabling input signal is normally linked with the pickup of the external protection device (see Figure 7-10). Another common configuration is the parallel wiring of the external trip initiation to both binary inputs (start and release).

Parameter: Supervision time release signal

- Default setting (_:111) Sup.time for release signal = 0.06 s

The setting depends on the external function which generates the release signal. If the pickup or tripping of the external protection is used as release signal, the default setting can be kept. If it is ensured that the release signal is always present before the starting signal, the time can be set to 0.

Parameter: Holding internal signal

- Recommended setting value (_:105) Holding int. start signal = yes

Parameter Value	Description
yes	For an internal start, the starting signal is held by default. The dropout of the CBFP depends exclusively on the determination of the CB position. This setting must be selected if it is not ensured that all 3 poles of the CB have opened when the pickup signal of the protection function has a falling edge. Siemens recommends using this method as the standard method.
no	Holding of the starting signal can be disabled if it is ensured by the application that the CB has reliably opened when the starting signal has a falling edge, or if the CBFP is explicitly required to dropout when the starting signal has a falling edge.

EXAMPLE

Holding internal starting signal (setting value: yes)

In the event of a 2-pole fault, only one contact of the CB opens. The fault current is thus reduced, and the starting phase short-circuit protection drops out.

Parameter: Holding ext. start signal

- Recommended setting value (_:106) Holding ext. start signal = no

Parameter Value	Description
no	The CBFP drops out when the external starting signal has a falling edge. This setting prevents the CBFP from generating a tripping signal when an unwanted pulse is received at the binary input and the current flow is high enough. Siemens recommends using this method as the standard method.
yes	You can hold the starting signal if it is not ensured that the circuit breaker is open when the external starting signal has a falling edge.

EXAMPLE

Holding external starting signal (setting value: yes)

The function is started from the opposite end via an auxiliary device for command transmission. This device generates only a signal pulse.

NOTE

Siemens would like to point out that, with a held signal, the CBFP generates a trip signal each time a starting pulse is received and the current flow is high enough. Remember this particularly in the case of an external start.

Parameter: Threshold phase current/Threshold sensitive

- Recommended setting value (_:102) Threshold phase current = approx. 0.50 $I_{sc,min}$
- Recommended setting value (_:103) Threshold sensitive = approx. 0.50 $I_{sc,min}$

In order to ensure that the disconnection of the fault is promptly detected and the function can drop out quickly, Siemens recommends setting both thresholds to half the minimum short-circuit current ($I_{sc,min}$).

If – depending on the neutral-point treatment and/or load conditions – ground faults lead to relatively low fault currents, a sensitive setting of the parameter Threshold sensitive must be selected according to the rule (0.5 $I_{sc,min}$). There can also be values which are noticeably below the rated or load current.

Input Signal: >Threshold sensitive

In order to ensure that the function picks up reliably in all switch positions of the power-supply system (example: opposite end of line open, switching onto a ground fault), the setting of the parameter Threshold sensitive can be applied dynamically to all currents – including phase currents – in the presence of ground faults. For this purpose, the binary signal >Threshold sensitive must be activated. This can be done via a device-internal function for ground-fault detection (if provided in the device), for example, using Overvoltage protection with zero-sequence voltage. In this case, the pickup of the V0> function must be linked with the binary signal. Alternatively, the signal can be coupled from a separate device for sensitive ground fault detection via a binary input.

Parameter: Circuit-breaker auxiliary-contact criterion allowed for protection

- Recommended setting value (_:101) CB aux.cont. crit. allowed = no

Parameter Value	Description
no	If sufficient current flow is ensured under all conditions with the CB closed, Siemens recommends not to permit the auxiliary contacts as a further criterion for determining the CB position, because measurement based on the current flow is the most reliable criterion.

Parameter Value	Description
w. 'CB pos. closed 3p.'	The auxiliary contacts are permitted as a further criterion in applications (see the following examples) where the current is no reliable criterion for determining the circuit-breaker position.

Parameter: 3I0 criterion

- Recommended setting value (_:120) 3I0 criterion = Plausibility check

Parameter Value	Description
Plausibility check	The ground current serves only for the plausibility check of the phase currents. The threshold for the ground current uses the value set in the Threshold sensitive parameter.
Direct release	The current flow criterion can be satisfied only by the ground current without the phase currents exceeding the set threshold value. The threshold for the ground current uses the value set in the Threshold 3I0 dir. release parameter in this case.

Parameter: I2 criterion

- Recommended setting value (_:121) I2 criterion = Plausibility check

Parameter Value	Description
Plausibility check	The negative-sequence current serves only for the plausibility check of the phase currents. The threshold for the negative sequence current uses the value set in the Threshold sensitive parameter.
Direct release	If one phase current exceeds 1/4 of the Threshold I2 dir. release, the current-flow criterion can be satisfied just by the negative-sequence current without the phase currents exceeding their set threshold value. The threshold for the negative sequence current uses the value set in the Threshold I2 dir. release parameter in this case.

EXAMPLES

Applications which require you to permit the circuit-breaker auxiliary-contact criterion:

- Tripping of the high and low-voltage side CB of the transformer. If only one of the 2 CBs trips, there is no more current flow.
- Tripping of protection functions whose tripping decision is not based on current measurement, in combination with low load situations.
- Injection of the tripping signal from Buchholz protection

Parameter: Dropout

- Recommended setting value (_:104) Dropout = with effective criterion

The parameter Dropout is available if the circuit-breaker auxiliary contact criterion is permitted (see parameter CB aux.cont. crit. allowed).

Parameter Value	Description
with effective criterion	Siemens recommends keeping the default setting, because it prefers the current as a reliable criterion for detection of an open CB and thus the dropout of the CBFP function.
w. aux.c. and curr.crit.	Select this setting for applications on transformers or generators (see the preceding examples) in which the current flow is such that the current is no longer a reliable criterion for detecting the opening of the CB.

Parameter: Retrip

- Default setting (_:108) Retrip after T1 = no

Parameter Value	Description
no	Where no redundant CB control is provided, a repetition of the trip signal to the local CB is not required.
start T2 after T1	Where a redundant CB control (2nd trip coil with 2 trip circuits) is provided, a repetition of the trip signal to the local CB makes sense. Siemens recommends the setting start T2 after T1 because it provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember here that the overall fault-clearance time in case of a failure of the local CB is the sum of T1 and T2.
parallel start T2, T1	As an alternative to the setting start T2 after T1, the user can start T2 and T1 in parallel.

Parameter: Delay T1 for 3-pole retrip

- Default setting (_:109) Delay T1 for 3-pole retrip = 0.05 s

The parameter is visible only when retripping is set.

The setting depends on the user's philosophy.

The following settings make sense:

- If the minimum fault clarification time has top priority, Siemens recommends setting the time to 0. This setting causes initiation of the retrip immediately upon the start. The drawback is that a defect of the 1st trip circuit is not detected.
- With a small time delay of, for instance, 50 ms, the defect of the 1st trip circuit can be detected based on the evaluation of the fault record.
- With a long time delay which reliably ensures the dropout of the CBFP with the CB open, the rising edge indication of the trip repeat Retrip T1 is a sure signal for a fault in the 1st trip circuit. The following example shows how this time is determined.

EXAMPLE

Determining the T1 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by the device internal protection)	5 ms
CB interrupt time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T1)	130 ms

Parameter: Delay T2 for 3-Pole Trip

- Default setting (_:110) Delay T2 for 3-pole trip = 0.13 s

This setting has to ensure that after opening of the local CB the function drops out reliably and that backup tripping is avoided under all circumstances. The setting depends on the parameter Retrip after T1.

If T2 is started after T1, there is no need to consider the time T1 for the setting of T2.

EXAMPLE

Determining the T2 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

288

Time of binary device output (when tripping is caused by the device-internal protection)	5 ms
CB inherent time up to current interruption	2 periods (at assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T2)	130 ms

If T1 and T2 are started in parallel, take into account the time T1 for the setting of T2.

EXAMPLE

Simultaneous start of T2 and T1

Time for a reliable dropout after the local CB has opened	130 ms
Setting of T1	50 ms
Total (= T2)	180 ms

Parameter: Minimum operate time

- Default setting (_:112) Minimum operate time = -

The Minimum operate time parameter is used to set the minimum duration for tripping the function.

CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger (dropout of the function without the current-flow criterion) that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

- Set a duration that is long enough to ensure that the circuit breaker reaches its final position open reliably after a control operation.

Input Signal: >CB defect

The input signal >CB defect has a default filtering time of 20 ms. This filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the pressure change when the CB opens.

This time can be set to 0 if such a transient pickup of the physical binary input can be excluded due to the CB design.

Output Signal: Retrip T1

If only one control circuit is available for the local CB, it is not mandatory to route the output signal because the signal also controls the CB trip logic.

If a 2nd control circuit is present, the output signal Retrip T1 must be routed to the associated binary output.

Output Signal: Trip T2

In order to operate the adjacent circuit breakers, the backup tripping (indication Trip T2) must be routed to a binary output and, if necessary, to an interface (intertripping to opposite end).

7.1.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
SOBF CB fail.1.#				
_:1	SOBF CB fail.#:Mode		• off • on • test	on
_:105	SOBF CB fail.#:Holding int. start signal		• no • yes	yes
_:107	SOBF CB fail.#:Start via binary input		• no • 2 channel • 1 channel	no
_:106	SOBF CB fail.#:Holding ext. start signal		• no • yes	no
_:111	SOBF CB fail.#:Sup.time for release signal		0.06 s to 1.00 s	0.06 s
_:103	SOBF CB fail.#:3I0 crit. cons. allowed		• no • w. "CB pos. closed 3p"	no
_:104	SOBF CB fail.#:Dropout		• with effective criterion • w. aux.c. and curr.crit.	with effective criterion
_:108	SOBF CB fail.#:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	no
_:102	SOBF CB fail.#:Threshold phase current	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 @ 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
_:101	SOBF CB fail.#:Threshold sensitive	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:109	SOBF CB fail.#:Delay T1 for 3-pole retrip		0.000 s to 60.000 s	0.050 s
_:110	SOBF CB fail.#:Delay T2 for 3-pole trip		0.050 s to 60.000 s	0.130 s
_:112	SOBF CB fail.#:Minimum operate time		0.00 s to 60.00 s	0.10 s
_:120	SOBF CB fail.#:3I0 criterion		• Direct release • Plausibility check	Plausibility check
_:121	SOBF CB fail.#:I2 criterion		• Direct release • Plausibility check	Plausibility check
_:122	SOBF CB fail.#:Threshold 3I0 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:123	SOBF CB fail.#:Threshold I2 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:124	SOBF CB fail.#:Monit. time for BI ">Start"		0.05 s to 60.00 s	15.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:125	SOBF CB fail.#:Monit.time f.BI ">Release"		0.05 s to 60.00 s	15.00 s

7.1.6 Information List

No.	Information	Data Class (Type)	Type
SOBF CB fail.1.#			
_:501	SOBF CB fail.#:>Start	SPS	I
_:502	SOBF CB fail.#:>Release	SPS	I
_:82	SOBF CB fail.#:>Block function	SPS	I
_:503	SOBF CB fail.#:>CB defect	SPS	I
_:506	SOBF CB fail.#:>Retrip, quit ctrl. circ.	SPS	I
_:54	SOBF CB fail.#:Inactive	SPS	O
_:52	SOBF CB fail.#:Behavior	ENS	O
_:53	SOBF CB fail.#:Health	ENS	O
_:55	SOBF CB fail.#:Pickup	ACD	O
_:305	SOBF CB fail.#:Retrip T1	ACT	O
_:306	SOBF CB fail.#:Trip T2	ACT	O
_:302	SOBF CB fail.#:BI start stability mon.	SPS	O
_:304	SOBF CB fail.#:BI rel. st. no. rel. mon.	SPS	O
_:300	SOBF CB fail.#:Fail. BI "Start"	SPS	O
_:307	SOBF CB fail.#:Fail. no BI release	SPS	O
_:301	SOBF CB fail.#:Fail. BI "release"	SPS	O

7.2 Automatic Reclosing Function

7.2.1 Overview of Functions

The Automatic reclosing function:

- Automatically closes overhead lines after arc short circuits
- Is only permissible for overhead lines, because only the possibility of self-activated extinguishing of an arc short-circuit exists here
- Can be controlled by integrated protection functions and by external protection devices
- The automatic reclosing can occur through an external automatic reclosing function via binary inputs.

The automatic reclosing after switching off through a short-circuit protection is taken over by the automatic reclosing function (AREC). The following figure shows an example for the normal procedure with a two-time automatic reclosing where the second automatic reclosing attempt is successful.

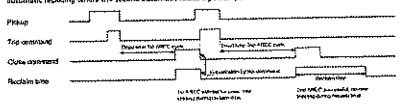


Figure 7-11 Process Diagram of a Two-Time Reclosing With Action Time (2nd Reclosing Successful)

The integrated Automatic reclosing function allows for up to 8 reclosing attempts. Each of the 8 disruption cycles can work with different parameters.

7.2.2 Structure of the Function

The automatic reclosing function is used in function groups for circuit breakers. In a function group for circuit breakers, one of the 3 types of functions illustrated in the following figures can be used. The Automatic reclosing function has a central function control.

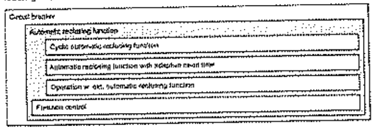


Figure 7-12 Structure/Embedding of the Function

Cyclic Automatic Reclosing Function

The Cyclic automatic reclosing function (Figure 7-13) allows for up to 8 reclosing attempts. Here each disruption cycle may work with different settings.

For the Cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete additional cycles from the function library in DIGSI 5.

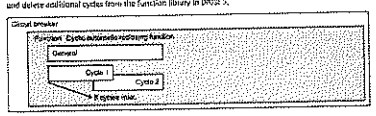


Figure 7-13 Structure/Embedding of the Cyclic Automatic Reclosing Function

Automatic Reclosing Function with Adaptive Dead Time

The Automatic reclosing function with adaptive dead time (ADT) works without fixed disruption cycles (Figure 7-14). The requirement for the usage of ADT is that voltage transformers on the line-side are connected or there is a possibility to transfer a close command to a remote line end. With the ADT, the Automatic reclosing function decides independently if and when an automatic reclosing is reasonable and permissible and when it is not. The criteria is the phase-to-ground voltage, which is switched through after reclosing from the opposite line end. The Automatic reclosing function with ADT occurs as soon as it is known that the line from the opposite end has been placed back under voltage.

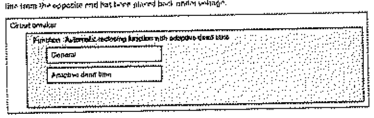


Figure 7-14 Structure/Embedding of the Automatic Reclosing Function With Adaptive Dead Time (ADT)

Operation with External Automatic Reclosing Function

The cooperation of an external reclosing device with the SIPROTEC protection device occurs through the function mode Operation with external automatic reclosing function (Figure 7-15). The function only provides binary inputs for the influence of the protection functions in the SIPROTEC protection device. The external automatic reclosing device delivers the close command. The SIPROTEC protection functions then provide for the trip commands.

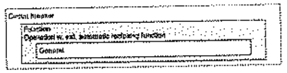


Figure 7-15 Structure/Embedding of the Operating Function With External Automatic Reclosing Function

Function Control

The automatic reclosing function contains a central function control, see the following figure. You can find detailed information on the function control in the section Function/Stage Control.

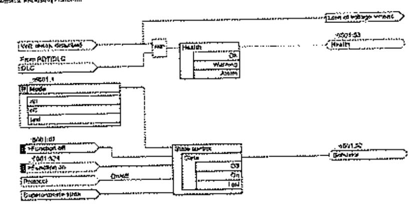


Figure 7-16 Function Control for the Automatic Reclosing Function

7.2.3 Cooperation of the Automatic Reclosing Function and Protection Functions

The Automatic reclosing function (AREC) can be influenced by the protection functions in the following ways:

- The AREC is started through pickup indications and operate indications by the selected protection functions or protection stages. The start is independent of the set operating mode for the AREC.
- Individual protection functions or protection stages can be configured so that their operate indication blocks the AREC. If such a blocking exists, the AREC cannot be started. If the AREC is already started, the blocking will lead to the cancellation of the AREC.

The automatic reclosing device can thus have an influence on the effects of the protection functions. The following influence possibilities exist:

- The AREC provides signals that can be used by protection functions for the blocking or release of special stages or zones. An example is the release of overreaching zones with distance protection.

289

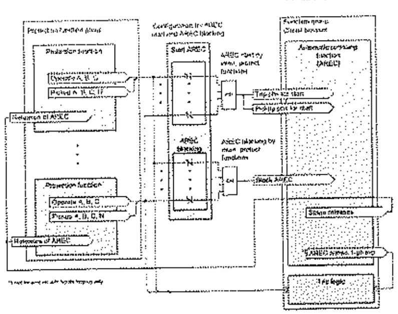


Figure 7-17 Signals between Protection Functions and Automatic Reclosing Functions

The configuration of the interaction between internal protection functions and automatic reclosing functions can be set separately for each protection function, see Figure 7-17. The configuration occurs in a matrix view in DIGSI, see the following figure.

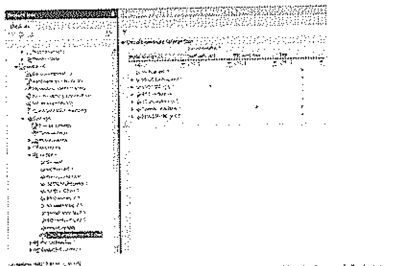


Figure 7-18 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI 5

If a protection function or the stage of a protection function is connected with the AREC through the matrix, this means that the respective pickup and operate indications are forwarded to the AREC.

The lines can be configured separately:

- For starting the automatic reclosing function and
- For the blocking of the automatic reclosing function

The Automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal Automatic reclosing function.

7.2.4 Cyclic Automatic Reclosing Function

7.2.4.1 Operating Modes for Cyclic Automatic Reclosing Function

For the cyclic automatic reclosing function, there are 4 operating modes, from which one can be selected for the parameterization (parameter (_:6601:101) 70 Operating mode).

The selection of the operating mode is dependent on the tripping behavior of the protection functions and the circuit breaker.

For applications with 3-pole tripping, all 4 operating modes are available.

- Operating mode 1: with op., with act. time
- Operating mode 2: w.pickup, w. action time
- Operating mode 3: with op., w/o act. time
- Operating mode 4: w.pickup, w/o act. time

Operating Mode 1: with op., with act. time

The operating mode with op., with act. time allows different automatic reclosing cycles depending on the tripping type and operate time of the protection function(s). With this operating mode, the automatic

reclosing must be started with the operate indications. Additionally, the general pickup must also be considered.

With rising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup >Gen. pickup for start.

Through the time between the rising general pickup and arriving operate indication, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example in Figure 7-19 shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Cycle 2 is now active.

Within the following reclaim time, there will be another pickup and tripping. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The 2nd operate indication comes during the running action time of cycle 3. Thus, cycle 3 is now active.

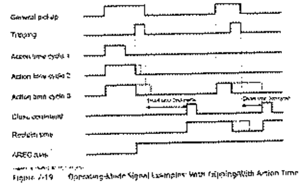


Figure 7-19 Operating Mode Signal Examples: With Tripping/With Action Time

Through the action time, there is a direct influence on the dead time behavior of the automatic reclosing function. With faults with short operate times, other dead times can be realized than for removed faults with longer tripping time. With faults with short operate time, an automatic reclosing is executed, with removed faults this does not occur with longer operate time. The operating mode with op., with act. time allows for different automatic reclosing cycles depending on the operate time of the protection function(s).

Operating Mode 2: w.pickup, w. action time

The operating mode w.pickup, w. action time allows different automatic reclosing cycles depending on the operate time and type of fault. It is only suitable and applicable for applications with 3-pole tripping.

With this operating mode, the automatic reclosing must be started with the operate indications from the protection functions. Additionally, the pickup sample from the conductor pickups and the general pickup are considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples phase-to-ground and only grounding.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup.

With rising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup >Gen. pickup for start.

Through the time between the rising general pickup and arriving trip command, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Since it is a 2-phase pickup, cycle 2 is active with the dead time setting for 2-phase faults.

After reclosing, there will be another, this time 3-phase, pickup and tripping within the following reclaim time. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The trip command comes during the current action time of cycle 3. Thus, cycle 3 is active, with the dead time setting for 3-phase faults.

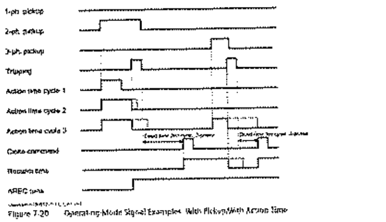


Figure 7-20 Operating Mode Signal Examples: With Pickup/With Action Time

Operating Mode 3: with op., w/o act. time

With the operating mode with op., w/o act. time, the respective dead time is started after each trip command. The pickups are not considered. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, and 3).

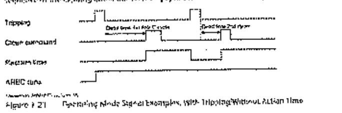


Figure 7-21 Operating Mode Signal Examples: With Tripping/Without Action Time

Operating Mode 4: w.pickup, w/o act. time

With the operating mode w.pickup, w/o act. time, the automatic reclosing must be started with the operate indications from the protection functions. It is only suitable and applicable for applications with 3-pole tripping.

The start of the dead time occurs after each trip command. Additionally, the pickup sample from the conductor pickups is considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples phase-to-ground and only grounding.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, 3, etc.).

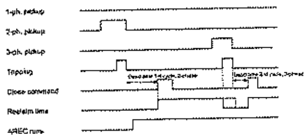


Figure 7-22 Operating Mode Signal Examples: With Pickup/Without Action Time

7.2.4.2 Structure of the Cyclic Automatic Reclosing Function

In Figure 7-23, the functional structure of the cyclic automatic reclosing function is illustrated as a block diagram. The figure displays the important signals, coming from outside of the cyclic automatic reclosing function, and the most important signals between the individual function blocks.

The automatic reclosing function works as a state machine. From the idle state **AREC ready**, the automatic reclosing function goes through the tripping or pickup indications of the protection functions to the **Dead time** state. After expiration of the dead time, the subsequent state is reached with the closing indication. The reclaim time is also started together with the closing indication. If the reclaim time can expire without further operate or pickup indications, the automatic reclosing is successful and the automatic reclosing function turns back to idle state.

If the automatic reclosing function is restarted during the current reclaim time, there will be either a dynamic blocking or other reclosing cycles will be executed. If other reclosing cycles are possible, there will be a dead time start and the described process starts again.

After the end of a dynamic blocking, the automatic reclosing function switches back to idle state or it goes into the state **Static Blocking** if the blocking condition is permanently present. In the following sections, the individual function blocks are described in detail.

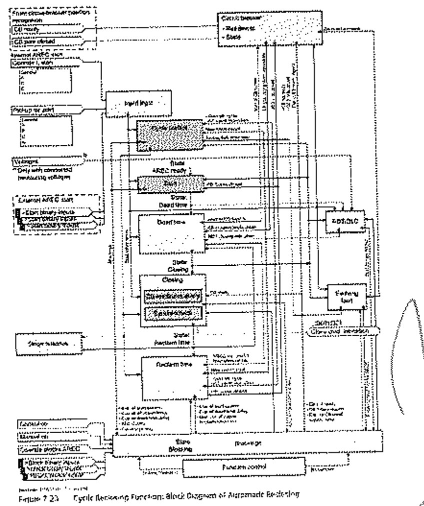


Figure 7-23 Cyclic Reclosing Function: Block Diagram of Automatic Reclosing

7.2.4.3 Input Logic for Operating Modes with Tripping

The operate indications are used as starting signals. For operating modes with action time, the start of the action time(s) occurs with the pickup messages. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

290

Applications with 3-Pole Tripping

For applications with only 3-pole tripping options, the internal operate indications are always 3-pole. For external starts, there is a binary input, which signalizes a 3-pole tripping of the external protection device. The outputs of the input logic signalize that the reclosing start has occurred through a 3-pole operate indication.

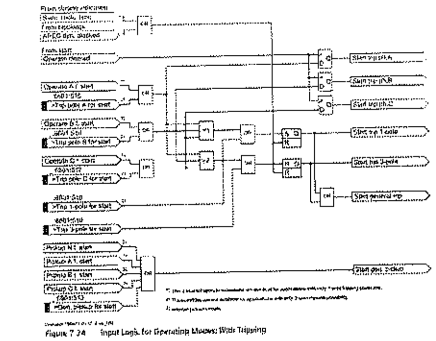


Figure 7-24 Input Logic for Operating Modes With Tripping

7.2.4.4 **Input Logic for Operating Modes with Pickup**

The operate indications and the pickup indications are used as starting signals. The internal pickup indications are processed selective to the phase. Through binary inputs the pickup information can also be coupled by external protection devices (>Pickup A for start, >Pickup B for start and >Pickup C for start). Optionally, the pickup information can be externally captured as a pickup sample, thus, as a 1-phase, 2-phase and 3-phase pickup.

The outputs of the input logic signalize if the automatic reclosing start occurs through a 1-phase, 2-phase, or 3-phase pickup:

- On Start with 3-phase pickup, it is recognized if all 3 phases were picked up in the period from the first raising pickup indication up to the last clearing outgoing pickup indication.
- On Start with 2-phase pickup, it is recognized if all 2 phases were picked up in the period from the first raising pickup indication up to the last clearing pickup indication and at no time 3 phases.
- On Start with 1-phase pickup, it is recognized if only 1 phase was picked up in the period from the first raising pickup indication up to the last clearing pickup indication.

For operating modes with action time, the start of the action time(s) occurs with the pickup indications. During operating modes with pickup, the pickup indications affect the selection of the dead times. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the dead time.

The automatic reclosing operating modes with pickups are only ideal for applications with 3-pole tripping. Therefore, the outputs of the input logic always signal 3-pole operate indications.

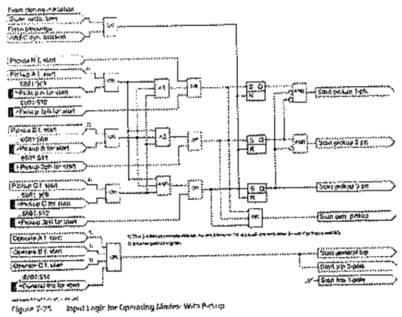


Figure 7-25 Input Logic for Operating Modes With Pickup

7.2.4.5 **Start**

In the Start function block, the automatic reclosing function is switched from the idle state AREC ready to the state Dead time, see Figure 7-26. The length of the starting signals is controlled with a supervision time.

Start-Signal Supervision Time

The start-signal supervision stops the automatic reclosing if the short circuit is not switched off within the normal time; for example, in the case of a circuit-breaker failure.

With the first raising operate indication, the start-signal supervision time is initiated, parameter Start signal supervis. time. The time is stopped as soon as no operate indications are active or if the circuit breaker is recognized as being no longer 3-pole closed.

The automatic reclosing function is blocked if there is an expiration of the start signal supervision time through a long operate indication. The blocking lasts until the operate indication stops, extended by a further 0.5 s.

Transition to the Dead-Time State

The transition of the automatic reclosing function to the dead-time state occurs for:

- Clearing operate indications if none of the signal inputs for operate indications are active
- or if the circuit breaker can no longer be recognized as 3-pole
- and the start-signal supervision time is not expired

Additionally, the following conditions must be fulfilled:

- The circuit breaker signalizes the readiness for automatic reclosing typically through a binary input. If the circuit breaker is not ready, the automatic reclosing function can be statically blocked. In this situation, the automatic closing function is not in idle state automatic closing function ready. The control of the circuit-breaker readiness is optional and can be turned off through settings, see also chapter 7.2.4.9 Circuit-Breaker Readiness and Circuit-Breaker Condition and 7.2.4.12 Blockings.
- The circuit breaker must be closed before the 3-pole trip command. This condition is not considered if the circuit breaker auxiliary contacts are not connected to the protection device.

You can delay the transition to the dead-time state through the binary input >Dead time start delay. As long the corresponding binary signal is present, the dead time of the automatic reclosing function will not be started. The maximum duration of this binary signal is monitored through a time stage that can be set, parameter Max. dead-time delay. Upon expiration of this time stage, that is, if the binary signal is present longer than permitted, the automatic reclosing function will be blocked until the end of the binary signal, additionally extended by another 0.5 s. See also chapter 7.2.4.12 Blockings.

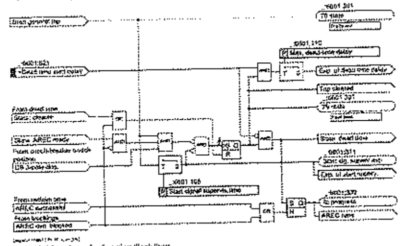


Figure 7-26 Logic for Function Block Start

7.2.4.6 **Cycle Control with Operating Mode 1: With Tripping/With Action Time**

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In Figure 7-27, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter Dead time aft. 3-pole trip to invalid avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing function if the Dead time

aft. 1-pole trip [1] is set to invalid. If both dead times are set to invalid, the respective automatic reclosing cycle will be completely blocked. With the binary input >Block 1. cycle, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (AR only after 1p. trip). The approval or switch over of special protection stages only occurs for types of faults that lead to 1-pole tripping.

Action Time

If the automatic reclosing function is in the idle state automatic reclosing function ready, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter Start from idle state allow. and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.

[1] Is only available for devices with 1-pole tripping

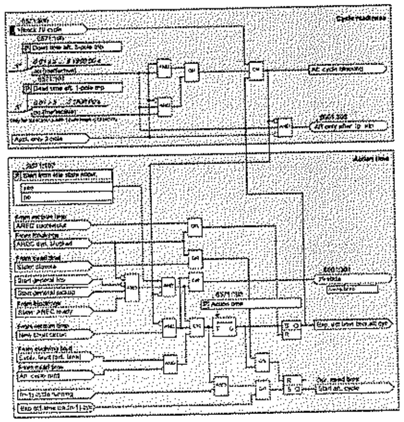


Figure 7-27 Cycle Control with Operating Mode, With Tripping/With Action Time

7.2.4.7 **Cycle Control with Operating Mode 2: With Pickup/With Action Time**

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In Figure 7-28, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter Dead time aft.1ph. pickup to invalid avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to Dead time aft.2ph. pickup and Dead time aft.3ph. pickup. If all 3 dead times are set to invalid, the respective reclosing cycle will be completely blocked. With the binary input >Block 1. cycle, you can block the associated automatic reclosing cycle.

Action Time

If the automatic reclosing function is in the idle state automatic reclosing function ready, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter Start from idle state allow. and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.

291

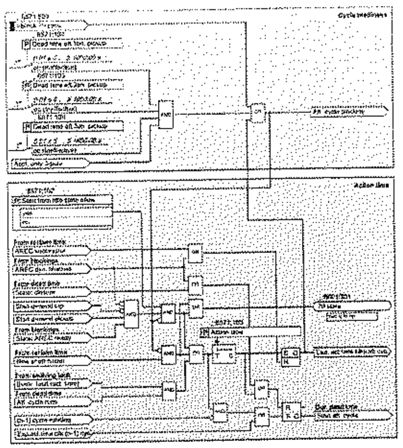


Figure 7-28 Cycle Control with Operating Mode: With Pickup/With Action Time

7.2.4.8 Cycle Control with Operating Mode 2: With Tripping/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In Figure 7-29, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number n and apply for all other configured automatic reclosing cycles.

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter Dead time aft. 3-pole trip to invalid avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing function after 1-pole tripping if the Dead time aft. 1-pole trip [1] is invalid. If both dead times are set to invalid, the respec-

[1] Only available for devices with only 1-pole tripping

tive automatic reclosing cycle will be completely blocked. With the binary input >Block 79 cycle, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only recloses after 1-pole tripping (AR only after 1p. trip). The operation or switch over of special protection stages only occurs for types of faults that lead to 1-pole tripping.

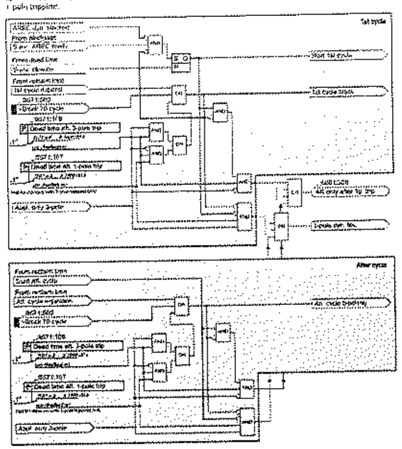


Figure 7-29 Cycle Control with Operating Mode: With Tripping/Without Action Time

7.2.4.9 Cycle Control with Operating Mode 4: With Pickup/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In Figure 7-30, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number n and apply for all other configured automatic reclosing cycles.

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter Dead time aft. 1ph. pickup to invalid avoids an automatic reclosing after 1-phase short circuit. This also applies to Dead time aft. 2ph. pickup and Dead time aft. 3ph. pickup. If all 3 dead times are set to invalid, the respective reclosing cycle will be completely blocked. With the binary input >Block 79 cycle, you can block the associated automatic reclosing cycle.

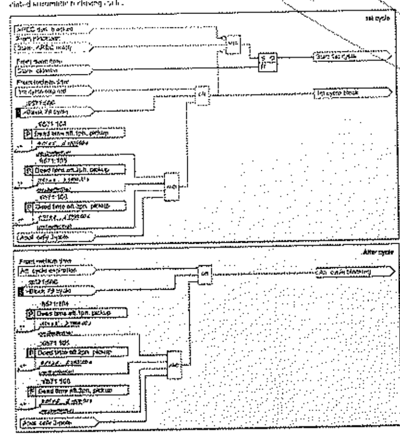


Figure 7-30 Cycle Control with Operating Mode: With Pickup/Without Action Time

7.2.4.10 Stage Release

The function block Stage release creates output indications for the release or switching over of special stages for protection functions (stage release in the 1st cycle or stage release in the n cycle). Examples for this are the release of overreaching zones with distance protection and the dynamic adjustment of delays or threshold values with overcurrent protection.

Figure 7-31 shows the tripping stage release for the 1st automatic reclosing cycle. With available automatic reclosing functions, the tripping stage release typically occurs up to the expiration of the dead time. The cycle number in this state is set 1. However, if the automatic reclosing cycle is set only for 1-phase [2], the tripping stage release will be reset to the beginning of the 1-phase dead time. This is necessary, since every additional evolving fault that occurs within the dead time causes a 3-pole cut-off, and subsequently, the automatic reclosing function can no longer take place.

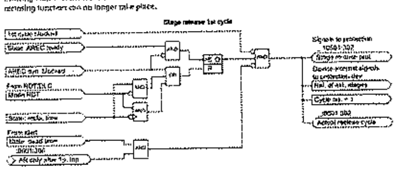


Figure 7-31 Stage Release for Protection Functions in the 1st Automatic Reclosing Cycle

The tripping stage release for higher automatic reclosing cycles is set to the beginning of the reclaim time for rising edge close commands. Simultaneously, the cycle number is increased. The reset condition is identical to the condition for the 1st automatic reclosing cycle. If the reduced dead time (RDT) mode is selected and no additional reduced dead time occurs, the release of the 2nd cycle will be maintained, since it can be assumed that the opposite end is open.

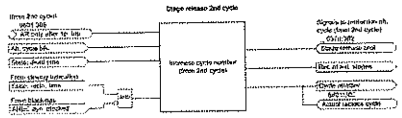


Figure 7-32 Stage Release for Protection Functions Starting With the 2nd Automatic Reclosing Cycle

7.2.4.11 Dead Time for Operating Modes With Tripping

In the Dead time function block, that dead time which corresponds with the previous trip command is started. After expiration of the dead time, the automatic reclosing function changes to the status Switch on. Figure 7-33 shows the dead time logic.

There are the following time stages that can be set differently:

- Dead time after 3-pole tripping
- Dead time after 1-pole tripping (only available for applications with 1-pole tripping)
- Dead time after evolving fault

[2] Only for devices with only 1-pole tripping

Setting the parameter Dead time aft. 3-pole trip to ∞ (= invalid) avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing after 1-pole tripping if Dead time aft. 1-pole trip is set to ∞ (= invalid).

As soon as an evolving fault is recognized (see chapter 7.2.4.13 Evolving-Fault Detection During Dead Time), switching to an automatic reclosing cycle for 3-pole interruption occurs. With the 3-pole cut-off of the evolving fault, a separate adjustable dead time for the evolving fault begins. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the first disruption plus the dead time for the evolving fault. With the setting of the parameter Dead time aft. evolv. fault to ∞ (= invalid), no other automatic reclosing cycle is executed after tripping by the evolving fault. The tripping through evolving faults is then finished.

3-pole Circuit-Breaker Condition With 1-Pole Tripping And Implausible Circuit-Breaker Condition

With applications with 1-pole tripping, during the dead time there is a plausibility check between the evaluated trip command and the flow of electricity in the open conductor. If the circuit-breaker auxiliary contacts are connected pole selectively, the plausibility check also occurs with the circuit breaker auxiliary contacts. More information can be found in the chapter 7.2.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition.

The plausibility check determines whether the circuit-breaker poles that have not been switched off after a 1-pole trip command remain closed.

For an implausible circuit breaker condition, a 3-pole trip command synchronization for the circuit breaker is executed, provided the trip command synchronization through the parameter is permitted (parameter 3-pole operate by 79). After this 3-pole tripping, if set and not blocked, more 3-pole automatic reclosing cycles may follow.

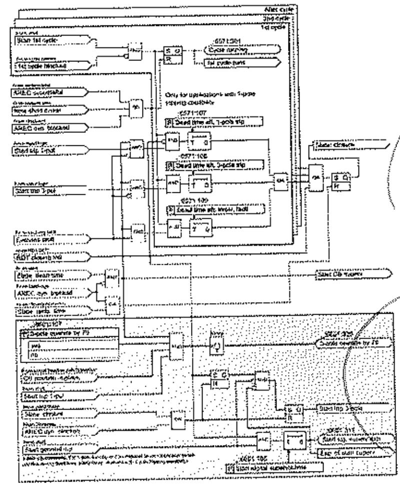


Figure 7-33 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes With Tripping

7.2.4.12 Dead Time for Operating Modes with Pickup

In the dead time function block, the dead time corresponding to the type of short circuit that led to the trip command is started. The automatic reclosing operating modes with pickup are only ideal for applications with 3-pole tripping. After expiration of the dead time, the automatic reclosing function changes to the status Switch on. Figure 7-34 shows the dead time logic.

292

There are 4 time stages that can be set differently:

- Dead time after 1-phase short circuits
- Dead time after 2-phase short circuits
- Dead time after 3-phase short circuits
- Dead time for evolving faults

In this way, setting the parameter Dead time aft.1ph. pickup to zero/infinite avoids an automatic reclosing after 1-pole tripping due to 1-phase short circuits. This also applies to Dead time aft.2ph. pickup and Dead time aft.3ph. pickup.

As soon as an evolving fault is recognized (see chapter 7.2.4.13 Evolving-Fault Detection During Dead Time), a separate dead time for faults begins with the tripping of the fault. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the 1st disruption plus the dead time for the evolving fault. With the setting of the Dead time aft. evolv. fault to infinite, no other automatic reclosing cycle is executed after tripping through the evolving fault. The tripping through evolving faults is then finished.

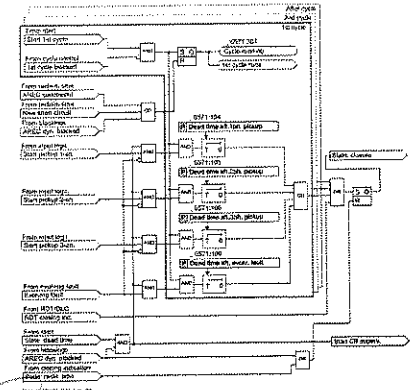


Figure 7-34 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes With Pickup

7.2.4.13 Evolving-Fault Detection During Dead Time

Evolving faults are short circuits, which occur after switching off a short circuit during dead time. This may be the case during 1-pole tripping and there is a short circuit on the not switched conductors after this.

After 3-pole tripping there may also be evolving faults if the line is fed through a second (not 3-pole) opened circuit breaker, for example, for systems with a 1 1/2 circuit-breaker layout.

The evolving fault detection is divided into components:

- Detection of Evolving Faults
- Evolving Faults Processing
- 3-pole circuit-breaker intertripping during evolving faults

The procedure during evolving faults is illustrated in Figure 7-35.

Detection of Evolving Faults

For the detection of an evolving fault, the following criteria can be selected through parameters:

- Parameter Evolving-fault detection = with trip
  For this setting, any tripping during the dead time leads to evolving-fault detection. At any tripping it is decided if an internal protection function is tripped or if the tripping is signaled through a binary input. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not.
- Parameter Evolving-fault detection = with pickup
  Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is recognized through a binary input.
- Binary input >Evolving fault start
  The evolving fault detection can also be introduced through a binary input without an internal protection pickup being available.

Reaction to Evolving Faults

After a recognized evolving fault, the automatic reclosing function can be influenced in 2 ways.

- Parameter Response to evolv. faults = blocks 79
  As soon as an evolving fault is recognized, the reclosing function will be blocked. There are no other reclosing attempts and the automatic reclosing function is blocked until the pickup and operate indications causing the evolving fault disappear.
- Parameter Response to evolv. faults = strt. evol.flt.dead time
  As soon as an evolving fault is recognized, an automatic reclosing cycle for 3-pole interruption is switched to. The automatic reclosing function does not allow any 1-pole tripping until the fault is solved or there is a final switch off. Thus, every following trip command will be 3-pole. When the evolving fault is fixed, the separate dead time for faults will start, see also chapter Dead time. The further process is as by 3-pole cycles.

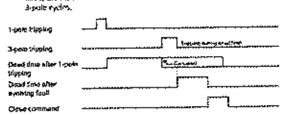


Figure 7-35 Cyclic Automatic Reclosing Function - Example for an Evolving Fault

For tripping through evolving faults, the entire dead time consists of the part of the dead time expired until disconnecting the evolving fault for the 1-pole interruption plus the dead time for the fault together (see Figure 7-35).

The dead time for evolving faults is started with the return of the operate indication or with the opening of all 3 circuit-breaker poles, provided the circuit-breaker auxiliary contacts are connected.

3-Pole Tripping of the Circuit Breaker for Automatic Reclosing Function Blocking through Evolving Faults in a 1-Pole Dead Time

If due to an evolving fault there is a blocking of the automatic reclosing function in the 1-pole dead time without a protection function submitting a 3-pole trip command, for example, during an evolving-fault detection with pickup, the automatic reclosing function can create a 3-pole trip command. Thus, the circuit breaker will have 3-pole tripping in which the blocking of the automatic reclosing function will occur.

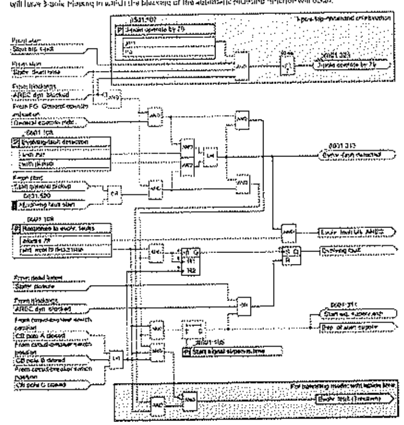


Figure 7-36 Cyclic Automatic Reclosing Function - Logic of Evolving-Fault Detection

7.2.4.14 Closing Indication and Close Command

After the expiration of the dead time, the automatic reclosing function will be in the closing state.

The closing state can depend on the following influences, see Figure 7-37:

- Through a synchrocheck if the circuit breaker was opened during the 3-pole dead time
- Through the readiness of the circuit breaker signaled through the binary input
- Through a binary input for delaying the close command (>Delay close cmd.)

The Close cmd. indication is a requirement for the assignment of the actual close command to the circuit breaker.

The mentioned criteria must not be fulfilled directly after expiration of the dead time. If a dead-time prolongation is set, the mentioned criteria will be checked during the prolongation. With the release of the closing indication, the automatic reclosing function will switch to the reclaim time state.

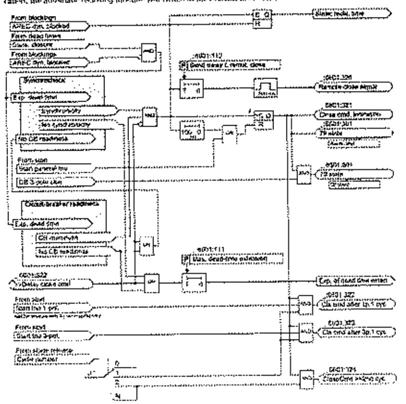


Figure 7-37 Cyclic Reclosing Function: Logic for the Closing Indication

Testing the Circuit-Breaker Readiness Directly before Closing

For each of the automatic reclosing cycles, you can set if a test of the circuit-breaker readiness should occur directly before closing (parameters CB ready check bef.close, Figure 7-38). Independent of this, a test of the circuit-breaker readiness before the start of the 1st automatic reclosing cycle can be set, see Chapter 7.2.4.5 Start and chapter 7.2.4.16 Circuit-Breaker Readiness and Circuit Breaker Condition.

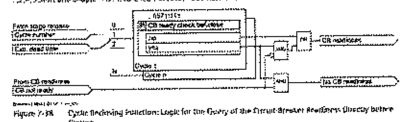


Figure 7-38 Cyclic Reclosing Function: Logic for the Query of the Circuit-Breaker Readiness Directly before Closing

Synchrocheck

For each of the configured automatic reclosing cycles, you can set if a synchrocheck should be executed and which functionality should be used here, see Figure 7-39. You may only use the internal synchrocheck if the device is connected to a voltage transformer.

Alternatively, you can also connect an external device with synchrocheck through a binary input.

The measuring request for the synchrocheck is placed if the optional test of the circuit-breaker readiness was positive. The measuring request for the synchrocheck exists until the synchrocheck assigns the allowance for the closure. If the allowance is not given within the set maximum dead time extension, the closure will be cancelled through the blocking of the automatic reclosing function. The minimum duration of the measuring request is 50 ms.

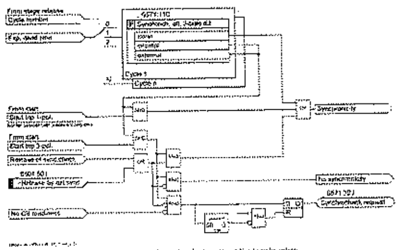


Figure 7-39 Cyclic Reclosing Function: Logic for the Inquiry of the Synchronism

Close Command

As soon as the test of the circuit-breaker readiness and the synchrocheck deliver a positive result, the closing indication will be created. It will be assigned for 100 ms. The actual close command is not created by the automatic reclosing function, but rather from the circuit-breaker function block outside of the automatic reclosing function. Here the set maximum duration of the close command is also considered.

In addition to the closing indication, additional indications will be created that describe the type of closure. These include:

- Close command after 1-pole tripping in the 1st cycle (Cls. cmd. after 1p.1.cyc)
- Close command after 3-pole tripping in the first cycle (Cls. cmd. after 3p.1.cyc)
- Close command after 1-pole or 3-pole tripping starting with the second cycle (Close cmd. >=2nd. cyc)

Creation of the Signal Remote close signal

The cyclic automatic reclosing function can create information Remote close signal. This information can be transferred to the protection device as a binary signal on the line that is to be protected on the opposite end. From the reclosing function, it can be processed in the operating mode adaptive dead time (ADT). Furthermore, the binary signal may be arranged as data for transmission via an existing protection interface.

The information Remote close signal is created by the closing logic. It can be delayed by a set time over the local close indication. With this delay, you can make sure that information is only set if the automatic reclosing was successful and there was no further tripping. The pulse duration of the inter close signal has a fixed length of 500 ms.

7.2.4.15 Reclaim Time

With the assignment of the close command, the automatic reclosing function goes into the reclaim time state. During this time, it is decided if the current reclosing cycle was successful or not.

- If during the reclaim time no further tripping occurs, the currently running automatic reclosing cycle, and thus the entire automatic reclosing, was successful.
- If during the reclaim time another tripping occurred, the currently running automatic reclosing cycle was not successful. If other automatic reclosing cycles are permitted, one of these cycles will be used to continue the process. If, in contrast, the currently executed cycle was the last permissible cycle, the automatic reclosing process will end and be reported as unsuccessful.

In both cases, the automatic reclosing function switches back to the idle state automatic reclosing function ready.

Short Circuits during Running Reclaim Time

A trip command that occurs during a reclaim time leads to a cancellation of the reclaim time. If further automatic reclosing cycles are allowed, the regulation of the cycle depends on if the automatic reclosing function is executed in an operating mode with action times or without action times, see Figure 7-40.

- With operating modes with action time, the action times of all higher cycles are started with the beginning of the new general pickup if these are not blocked. The cycle with the lowest cycle number is selected, whose action time is not yet expired with the incoming trip indication. If no further cycles are possible or if the action times of all possible cycles are expired before the operate indication, there will be no further reclosing.
- With the operating modes without action time, the cycle following the current cycle will always be selected in the set cycle. If this is blocked, the cycle following this one will be selected, etc. If no higher cycles exist or if they are all blocked, there will be no further automatic reclosing.

293

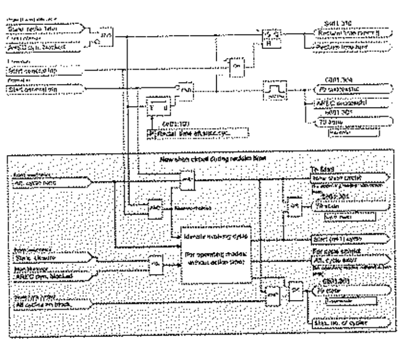


Figure 7-40 Cyclic Reclosing Function: Logic for the Reclaim Time

7.2.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition

The automatic reclosing function requires the readiness of the circuit breaker for the following purposes, see Figure 7-41:

- Recognition of the circuit-breaker readiness from the beginning:
  In idle state of the automatic reclosing function, an unavailable circuit breaker leads to the blocking of the automatic reclosing function. This monitoring is optional and must be switched off through settings if the readiness signal is not available for the protection device.
- Analysis of the circuit breaker readiness directly before the close command:
  For each of the configured automatic reclosing cycles, it can be set whether the circuit-breaker readiness is a requirement for the assignment of the close command. This monitoring is also optional.

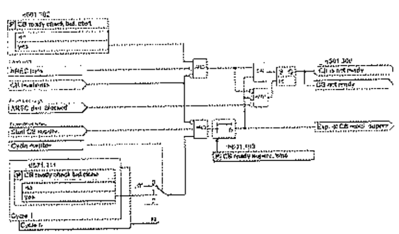
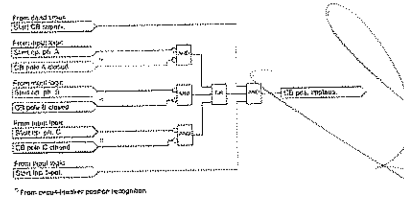


Figure 7-41 Cyclic Reclosing Function: Logic for the Circuit-Breaker Readiness

The automatic reclosing function uses the information from the circuit breaker for the following purposes (see Figure 7-42):

- Detection of a non-closed circuit breaker before the start:
  In idle state of the automatic reclosing function, a non 3-pole closed circuit breaker leads to the blocking of the automatic reclosing function, see also chapter 7.7.4.17 Blockings. This monitoring is not needed if the auxiliary-contact signals are not available.
- Detection of the reaction of the circuit breaker after a trip command:
  The automatic reclosing function dead time is started immediately with the opening of the circuit breaker if the circuit-breaker auxiliary contacts are connected. Here a decision is made based on the tripping of the circuit breaker if the circuit breaker is no longer 3-pole closed.
  An exception is the reaction to an evolving fault. As the circuit breaker already has 1 pole open before the occurrence of an evolving fault, the dead time is started if the circuit breaker is detected as having 3 poles open.
  If the circuit-breaker auxiliary contacts are not connected, the automatic reclosing function dead time will start with the dropout of the operate indication.
- After a 1-pole trip, a check is done during the dead time to determine whether the circuit-breaker poles that were not switched off remain closed. The circuit-breaker position recognition is delivered from the central circuit-breaker position recognition of the Circuit-breaker function group.
  For implausible circuit breaker condition, a 3-pole trip command synchronization for the circuit breaker is executed provided the settings allows this. After this 3-pole tripping, if set and not blocked, more 3-pole automatic reclosing cycles may follow, see also chapter 7.7.4.11 Dead Time for Operating Modes With Tripping.



[1] From circuit-breaker position recognition

Figure 7-42 Cyclic Reclosing Function: Logic for Circuit-Breaker Condition and Supervision

7.2.4.17 Blockings

The automatic reclosing function differentiates between 2 types of blockings, see Figure 7-43:

- Static blocking
- Dynamic blocking

Static Blocking

The automatic reclosing function is statically blocked if the function is switched on, but is not ready for reclosing and also cannot be started as long as this blocking is present. The dynamic blocking is signaled with the indication Inactive.

The following conditions lead to the static blocking:

Condition	Indication
Manual closing of the circuit breaker, recognition through binary input or internal device control. The blocking is temporary, the duration can be set with the parameter Block. time aft. man.close.	Inactive
Circuit breaker not available for automatic reclosing function, recognition through binary input. This cause can be switched on or off through the parameter CB ready check bef. start.	Inactive
Circuit breaker of non-closed 3-pole, recognition through binary input. This criteria is used if the circuit-breaker auxiliary contacts are connected.	Inactive

Condition	Indication
No reclosing cycle possible Recognition due to the following causes: • Automatic reclosing cycle is not set. • Automatic reclosing cycles are set, but all are blocked, for example, via binary input. • There is no internal device function and no binary input configured for starting the automatic reclosing function. • With operating modes with tripping: – both 1-pole and 3-pole cycles are blocked via binary inputs. • With operating modes with pickup: – 1-phase, 2-phase and 3-phase automatic reclosing cycles, the blocking is done through binary inputs. • With operating modes without action time: – the first automatic reclosing cycle is blocked via binary input. • With the dead-line check functionality: – if the voltage measurement is not available or is disrupted	Inactive

Dynamic Blocking

The automatic reclosing function is blocked dynamically if a blocking condition occurs while an automatic reclosing function is running. The dynamic blocking is signalized with the indication Not ready.

After the occurrence of a dynamic blocking, it is checked in intervals of 0.5 s to see if the blocking can be removed. If the blocking condition remains or if a different blocking condition occurs in the meantime, the blocking will remain. If, in contrast, the cause of the blocking disappears, the dynamic blocking will be removed if no general pickup or no tripping configured for the automatic reclosing function start is available.

A separate indication for logging exists for each individual blocking cause.

The following conditions lead to the dynamic blocking:

Condition	Indication
If no reclosing cycle fitting the fault type is released: • With operating modes with tripping: If a 1-pole or 3-pole operate indication occurs during the automatic reclosing function start input, however, the automatic reclosing function does not start in accordance with the parameterization for this type of tripping, the respective dead time will be set to invalid. • With operating modes with pickup: If a 1-phase, 2-phase or 3-phase pickup indication occurs during the automatic reclosing function starting process, but the automatic reclosing function may not be started in accordance with the parameterization for this type of pickup.	Not ready Block. by no cycle
If a protection function causes the automatic reclosing function to be blocked in accordance with the configuration	Not ready Block. by protection
If the maximum set waiting time for the delay of the start of the dead time through the binary input >Dead time start delay expires without the binary input becoming inactive during this time lapse	Not ready Blk by max. d.t. delay
If the synchrocheck is set and the synchronism conditions after the expiration of the maximum dead time prolongation are not fulfilled before the assignment of the close command	Not ready Blk.by max.d.t. expiry

Condition	Indication
If the enquiry of the circuit-breaker readiness is switched on directly before the close command through the parameter and the maximum dead time prolongation expires	Not ready Blk.by CB ready sup. Blk.by max.d.t. expiry
If the closing indication is delayed through the binary input >Delay close cmd. for so long until the maximum dead time extension is exceeded before the assignment of the close command	Not ready Blk.by max.d.t. expiry
If an evolving fault occurs and the parameter Response to evolv. faults is set to blocks AR	Not ready Blk. by evolving fault
If the start-signal supervision time for the operate indication starting from the automatic reclosing function or the starting binary input expires. In this case, a circuit-breaker failure is assumed.	Not ready Blk.by startsig.superv.
If after the start of the automatic reclosing function a dead time is already running and a blocking binary input is active, with the following binary inputs: >Blk. 1-pole AR, >Blk. 3-pole AR, >Blk. with 1-ph pickup, >Blk. with 2-ph pickup, >Blk. with 3-ph pickup	Not ready Block. by binary input
If the maximum number of automatic reclosing attempts is reached and there is a trip command within the reclaim time	Not ready Block. by max. cycles
With operating modes with action time: If the action times of all released automatic reclosing cycles expire without a trip command	Not ready Blk.by action time exp
For applications with voltage measurement and switched on functionalities with dead-line check: If during the dead time the required voltage criteria is not fulfilled	Not ready Blk.by dead-line check
For applications with voltage measurement and switched on functionalities with dead-line check: If during a running automatic reclosing cycle a failure of the measuring voltage is determined. After the completion of the automatic reclosing cycle, the dynamic blocking becomes static blocking if there is a continued failure of the measuring voltage.	Not ready Blk.by loss of voltage

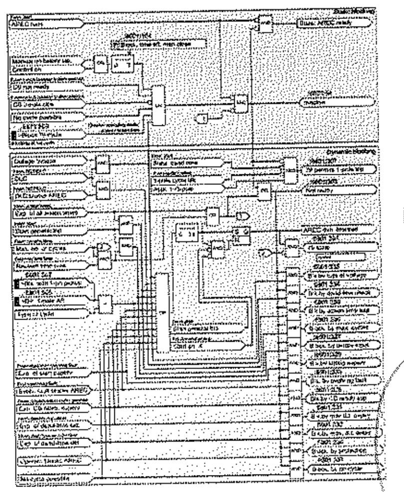


Figure 7-43 Cyclic Reclosing Function: Blocking Logic at the Example for a 1-Pole Cycle (Static and Dynamic Blocking)

7.2.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)

The additional functions Dead-line check (DLC) and Reduced dead time (RDT), are only possible for applications with a voltage-transformer connection. Another requirement is that the voltage of the line being switched on can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line side - seen from the circuit breaker.

Both additional functions DLC and RDT are mutually exclusive, because the DLC checks if the value falls below a voltage threshold, while the RDT checks if the value exceeds the voltage threshold.

The respectively selected additional function runs in the automatic reclosing state dead time.

Reduced Dead Time (RDT)

With the Reduced dead time, a close command can be assigned before the expiration of the set dead times if the line to switch on is recognized as fault-free through the measurement of the line voltage.

The voltage measurement occurs with the 3 phase-to-phase voltages.

In systems with a grounded neutral point, the 3 phase-to-ground voltages are additionally observed.

In systems with compensated or with isolated neutral points, the largest 2 of the 3 phase to ground voltages are additionally considered. Through this, a RDT can also be executed with 1-phase ground connections.

For the approval of the close command with RDT, the following conditions apply:

- The automatic reclosing function is in the state dead time.
- Each measured voltage is above the set threshold values Volt. thres. f. live line/bus
  The phase-to-phase voltages are divided by √3 prior to comparing the threshold value. Thus, the phase-to-ground voltage $U_n/\sqrt{3}$ applies as the reference size for the parameterization.
- Exceeding the threshold is fulfilled for the set duration Voltage supervision time.

Dead-Line Check (DLC)

If after switching off a short circuit the voltage on the switched off line does not disappear, the automatic reclosing function can be avoided with the dead-line check (DLC).

The voltage measurement occurs with the 3 phase to ground voltages.

For the release of the close command with DLC, the following conditions apply:

- The automatic reclosing function is in the state dead time
- All measured voltages for the set duration Voltage supervision time are below the set threshold Volt. thres.f. live line/bus.
- The set dead time is expired.

As soon as the voltages fall below the threshold value for the set duration, the allowance for automatic reclosing with DLC is assigned. This also applies if the values are not below the voltage threshold until the expiration of the set dead time. In this way, an automatic reclosure is executed if the automatic reclosing function is first switched to at the end of the protected line and thus, the line is exposed to voltage again.

The automatic reclosing function is blocked by the DLC under the following conditions:

- The automatic reclosing function is in the Closure state, the dead time has expired
- All measured voltages were not simultaneously below the set threshold values Volt. thres. f. dead line/bus for the set duration Voltage supervision time during the dead time.

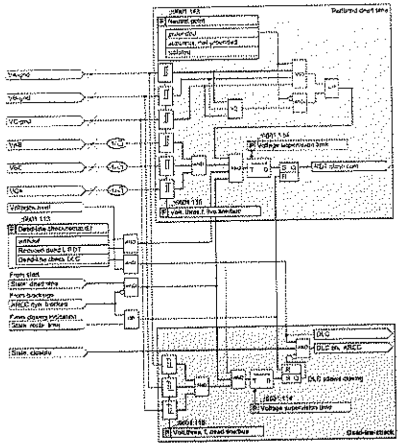


Figure 7-44 Cyclic Reclosing Function: Logic for the Functions of Reduced Dead Time and Dead-Line Check

7.2.4.19 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time

Addr.	Parameter	C	Setting Options	Default Setting
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.10 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:1-pole operate by 79		• no • yes	yes
_:6601:108	General:Evolving fault detection		• with trip • with pickup	with trip
_:6601:109	General:Response to evolv. faults		• strt. evol. flt.dead time • blocks 79	blocks 79
_:6601:110	General:Max. dead time delay		0.01 s to 300.00 s	0.50 s
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:112	General:Sum delay f. manual. close		0.00 s to 300.00 s; ∞	∞
DLC, RDT				
_:6601:113	General:Dead-line check/reduced.t		• without • Reduced dead t. RDT • Dead-line check DLC	without
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
_:6601:116	General:Volt. thres. f. dead line/bus		0.300 V to 340.000 V	30.000 V
Cycle 1				
_:6571:102	Cycle 1:Start from idle state allow.		• no • yes	yes
_:6571:101	Cycle 1:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6571:108	Cycle 1:Dead time aft. 3-pole trip		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:107	Cycle 1:Dead time aft. 1-pole trip		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:104	Cycle 1:Dead time aft. 1ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:105	Cycle 1:Dead time aft. 2ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:106	Cycle 1:Dead time aft. 3ph. pickup		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:103	Cycle 1:Dead time aft. evolv. fault		0.01 s to 1800.00 s	1.20 s
_:6571:111	Cycle 1:CB ready check bef.close		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:6571:110	Cycle 1:Synchrocheck aft. 3-pole d.t.		• none • internal • external	none
_:6571:112	Cycle 1:Intern. synchro-check with		Setting options depend on configuration	

7.2.4.20 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.Relic.	SPS	I
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:520	General:>Evolving fault start	SPS	I
_:6601:521	General:>Dead time start delay	SPS	I
_:6601:522	General:>Delay close cmd	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir.	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O

No.	Information	Data Class (Type)	Type
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:313	General:Evolv. fault detected	SPS	O
_:6601:314	General:RDT CloseCmd indicat.	SPS	O
_:6601:315	General:Dead t. aft. 1pole trip	SPS	O
_:6601:316	General:Dead t. aft. 3pole trip	SPS	O
_:6601:317	General:Dead t. aft. 1ph pickup	SPS	O
_:6601:318	General:Dead t. aft. 2ph pickup	SPS	O
_:6601:319	General:Dead t. aft. 3ph pickup	SPS	O
_:6601:320	General:Dead t. aft. evolv. flt.	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p,1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p,1.cyc	SPS	O
_:6601:324	General:CloseCmd >=2nd.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:326	General:Remote close signal	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strt.sig superv	SPS	O
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk by max.d.t. expiry	SPS	O
_:6601:332	General:Blk.by max. d.t. delay	SPS	O
_:6601:333	General:Blk. by evolving fault	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:334	General:Blk. by dead-line check	SPS	O
_:6601:335	General:Blk.by lack of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
_:6601:341	General:Cyc2+ 1p AR	INS	O
_:6601:342	General:Cyc2+ 3p AR	INS	O
Cycle 1			
_:6571:51	Cycle 1:Mode (controllable)	ENC	C
_:6571:500	Cycle 1:>Block 79 cycle	SPS	I
_:6571:52	Cycle 1:Behavior	ENS	O
_:6571:53	Cycle 1:Health	ENS	O
_:6571:301	Cycle 1:Cycle running	SPS	O
_:6571:302	Cycle 1:Stage release prot.	SPS	O
_:6571:303	Cycle 1:Synchrocheck request	SPS	O

7.2.5 Automatic Reclosing Function with Adaptive Dead Time (ADT)

7.2.5.1 Description

Considering the cyclic automatic reclosing function, it is assumed that defined and similar dead times were set at both line ends and, if applicable, they are set for different types of faults and/or disruption cycles.

It is also possible to set the dead times only at one line end and to configure the adaptive dead time at the other end or ends. The requirements for this is that the voltage transformer aligned on the line side or a possibility to transfer a close command to a remote line end exists.

Figure 7-45 shows an example with a voltage measurement. It is assumed that device I works with defined dead times, while the adaptive dead time is configured in device II. It is important that the line is at least fed from the busbar A, so from the side with the defined dead times.

With the adaptive dead time, the automatic reclosing function at the line end II decides independently if and when a reclosing is reasonable and permissible and when it is not. The criteria is the voltage of the line at the end II, which is switched through after reclosing from end I. The reclosing at end II occurs, as soon as it exists, so that the line from end I is set back under voltage. Basically, all phase-to-phase and phase-to-ground voltages are monitored.

With an applied short circuit, the lines at the positions I, II, and III in the example are switched off. Position I is switched on again after the dead time set there. At position III the reduced dead time (RDT) can be executed with the appropriate configuration (see chapter 7.2.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)) 7.2.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT) if an infeed is also available on busbar B.

If the short circuit has been cleared after successful reclosing, the line A-B from the busbar A will be set under voltage through the position I. Device II recognizes this voltage and switches on to warrant adequate voltage measurement time after a short delay. The system incident is thus successfully cleared.

If the short circuit is not cleared after closure at position I, I will be switched to the fault again. At line end II, now no healthy voltage will appear. The device here recognizes this and does not close again.

With multiple reclosing, the process may repeat if the reclosing is unsuccessful until one of the reclosings is successful or a final closing occurs.

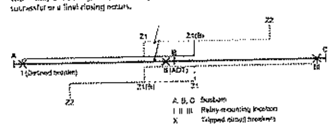


Figure 7-45 Example for Adaptive Dead Time (ADT)

As the example shows, the adaptive dead time brings along the following advantages:

- The circuit breaker at position II does not switch off again with a remaining fault and is protected through this.
- With a non-selective tripping through flashing over to position III, no more disruption cycles may exist there, because the short-circuit path through busbar B and the position II remains disrupted even with multiple reclosing.
- At position I, with multiple reclosing and even with a final tripping, an overlapping is not used, because the line at position II remains open and thus, no actual overreaching can occur at position I.

The adaptive dead time also contains the reduced dead time (RDT), because the criteria are the same. A special setting of the reduced dead time (RDT) is unnecessary if the automatic reclosing function is used with adaptive dead time (ADT).

295

7.2.5.2 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time after succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal supervis.time		0.01 s to 300.00 s	0.12 s
_:6601:106	General:CB ready monitor. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s or ∞	1.20 s
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thresh. live bus/line		0.300 V to 340.000 V	48.000 V
ADT				
_:6631:101	ADT:1-pole trip allowed		• no • yes	no
_:6631:104	ADT:Action time		0.00 s to 300.00 s or ∞	0.20 s
_:6631:105	ADT:Maximum dead time		0.50 s to 3000.00 s	5.00 s
_:6631:102	ADT:CB ready check bef.close		• no • yes	no
_:6631:103	ADT:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:6631:106	ADT:Intern. synchrocheck with		Setting options depend on configuration	

7.2.5.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:324	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I

No.	Information	Data Class (Type)	Type
_:6601:302	General:>Ext. with 1-ph pickup	SPS	I
_:6601:303	General:>Ext. with 2-ph pickup	SPS	I
_:6601:304	General:>Ext. with 3-ph pickup	SPS	I
_:6601:305	General:>Ext. 1-pole AR	SPS	I
_:6601:306	General:>Ext. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:312	General:Max. dead time expired	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cl.cmd after 1p.1.cyc.	SPS	O
_:6601:324	General:Cl.cmd after 3p.1.cyc.	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Bl. by CB ready sup.	SPS	O
_:6601:329	General:Bl. by synchr. superv.	SPS	O

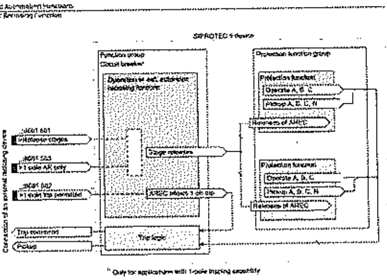
No.	Information	Data Class (Type)	Type
_:6601:330	General:Bl. by action time exp.	SPS	O
_:6601:331	General:Bl. by max.cycle expire	SPS	O
_:6601:332	General:Block. by no cycle	SPS	O
_:6601:334	General:Block. by protection	SPS	O
_:6601:335	General:Bl. by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cnt. 1p AR	INS	O
_:6601:340	General:Cnt. 3p AR	INS	O
ADT			
_:6631:51	ADT:Mode (controllable)	ENC	C
_:6631:501	ADT:>Remote close signal	SPS	I
_:6631:52	ADT:Behavior	ENS	O
_:6631:53	ADT:Health	ENS	O
_:6631:301	ADT:ADT is running	SPS	O
_:6631:302	ADT:Stage release prot.	SPS	O
_:6631:307	ADT:Synchrocheck request	SPS	O

7.2.6 Cooperation with External Automatic Reclosing Function

7.2.6.1 Description

The operation of an external reclosing device with the SIPROTEC protection device occurs through the function mode Operation with external automatic reclosing function. In this function mode, the SIPROTEC protection functions create the trip command and the external reclosing device creates the close command.

The following figure shows the interaction of an external reclosing device with the functions of the SIPROTEC 5 device.



[1] Only for applications with 1-pole tripping capability

Figure 7-46 Connection of an External Automatic Reclosing Function

There are no setting parameters for operation with external automatic reclosing functions. The function provides exclusively the following described binary inputs. The external reclosing device can thus have an influence on the effects of the internal protection functions.

The following connection possibilities exist:

- From the external reclosing function, the signal >Release stages can be coupled so that the protection functions use special stages or zones for release. An example is the release of an overreaching zone with a distance protection or the non-delayed tripping of an overcurrent protection stage in the 1st reclosing cycle.
- For applications with 1-pole tripping, the external reclosing can provide the signal >1-pole trip permitted, based on which the protection functions can switch off the 1-pole circuit breaker.
- For applications with reclosing functions only with 1-pole faults and stage or zone releases through the reclosing function can the signal >1-pole AR only be connected. The protection functions use this information to allow the stage or zone release only affect 1-pole faults.

7.2.6.2 Information List

No.	Information	Data Class (Type)	Type
Ext.			
_:6661:51	Ext:Mode (controllable)		C
_:6661:501	Ext:>Release stages		I
_:6661:502	Ext:>1-pole trip permitted		I
_:6661:503	Ext:>1-pole AR only		I
_:6661:52	Ext:Behavior		O
_:6661:53	Ext:Health		O
_:6661:54	Ext:Inactive		O

7.2.7 Application and Setting Notes for General Settings

For the automatic reclosing function, there are 3 functions available in the function library. In each circuit-breaker function group, a function from the automatic reclosing function can be used.

Configure one of the 3 following function specifications.

- Cyclic Automatic reclosing function
- Automatic reclosing function with Adaptive dead time (ADT)
- Operation with External Automatic Reclosing Function

Starting the Automatic Reclosing Function

The configuration of the interaction between internal protection functions and the automatic reclosing function can be set separately for each protection function. The configuration occurs in a matrix view in DIGSI. The Automatic reclosing function also has the corresponding binary inputs and binary outputs, through which the external protection devices can be connected to the internal Automatic reclosing function.

Configure the starting and blocking condition for the automatic reclosing function at the position shown in Figure 7-47 in DIGSI (for example, a protection function group Line is shown here) as route the corresponding binary inputs.

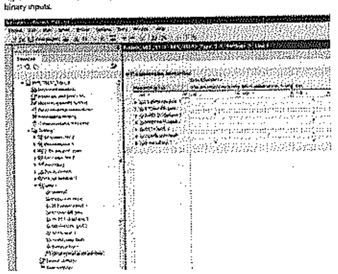


Figure 7-47 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI

General Settings

If you use the Cyclic automatic reclosing function or Automatic reclosing function with adaptive dead time function, set the following settings under General.

There are no settings for the function Operation with external automatic reclosing function. The control occurs exclusively through binary inputs and binary outputs.

Parameter: 79 operating mode

- Default setting (_:6601:101) 79 operating mode = with op., with act. time

You can use the 79 operating mode parameter to determine which start criteria the automatic reclosing function works with.

Parameter Value	Description
with op., with act. time	The automatic reclosing function cycles are dependent on the operate time of the protection function(s). The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. Siemens generally recommends this setting for applications with 1/3-pole tripping and for applications with 3-pole tripping if a single dead time, independent of the type of connection working, is required in the automatic reclosing function cycle. Detailed information can be found in Chapter 7.2.4.1 Operating Modes for Cyclic Automatic Reclosing Function, section Operating Mode 1
w.pickup, w. action time	The automatic reclosing function cycles are dependent on the operate time of the protection function(s) and the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. For applications with 3-pole tripping and dead time dependent on the circuit type, Siemens recommends this setting. Detailed information can be found in the chapter 7.2.4.1 Operating Modes for Cyclic Automatic Reclosing Function, section Operating Mode 2
with op., w/o act. time	Each operate indication starts the automatic reclosing function. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. Detailed information can be found in the chapter 7.2.4.1 Operating Modes for Cyclic Automatic Reclosing Function, section Operating Mode 3
w.pickup, w/o act. time	Each operate indication starts the automatic reclosing function. The automatic reclosing function cycles are dependent on the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. Detailed information can be found in the chapter 7.2.4.1 Operating Modes for Cyclic Automatic Reclosing Function, section Operating Mode 4

Parameter: CB ready check bef. start

- Default setting (_:6601:102) CB ready check bef. start = no

With the CB ready check bef. start parameter, you can determine if the readiness of the circuit breaker should be tested before starting the automatic reclosing function.

Additionally or alternatively, it is possible to check the readiness of the circuit breaker after the expiration of the dead time, directly before the assignment of the close command. There is another parameter described in the chapter 7.2.8 Application and Setting Notes for a Cycle of the Cyclic Automatic Reclosing Function for this function.

296

Detailed information about the functionality can be found in the chapter 7.2.4.12 Dead Time for Operating Mode with Tripping, 7.2.4.13 Evolving Fault Handling and 7.2.4.14 Evolving Fault Detection During Dead Time.

Parameter: Evolving-fault detection

The parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting (_:6601:108) Evolving-fault detection = with trip

With the Evolving-fault detection parameter, you can determine which criteria is used to recognize an evolving fault. The actual effect of the recognized evolving fault on the automatic reclosing function can be set with the parameter described below Response to evolv. faults.

Evolving faults are short circuits, which occur after switching off a short circuit during dead time.

You can find detailed information about evolving fault detection in the chapter 7.2.4.13 Evolving Fault Detection During Dead Time.

Parameter Value	Description
with trip	Evolving faults are recognized if an operate indication occurs during the dead time. Thus, it does not matter if the tripping protection function is configured for the start of the automatic reclosing function or not. The pickup of a protection function without an operate indication does not lead to evolving-fault detection.
with pickup	Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is detected through a binary input.

For applications with 1/3-pole tripping, Siemens recommends the setting with trip if the system is adequately overcompensated.

If multiple individual lines in a row form a total transmission path, the setting with pickup may be better suitable. With this setting, you can prevent 2 lines following each other from switching to 1-pole in different conductors during evolving faults. The consequence of this fault would be the remainders of a single conductor in the dead time for the overall transmission path. This is particularly important if power plants are coupled through the overall transmission path.

Parameter: Response to evolv. faults

The parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting (_:6601:109) Response to evolv. faults = blocks 79

With the Response to evolv. faults parameter, you can determine how the automatic reclosing function reacts to recognized faults.

You can find detailed information about the automatic reclosing function for faults in the chapter 7.2.4.13 Evolving Fault Detection During Dead Time.

Parameter Value	Description
blocks 79	The automatic reclosing function is immediately blocked until the disconnection of the fault. For blocking through faults during the 1-pole dead times, you can force a 3-pole trip command through the automatic reclosing function if you set the parameter 3-pole operate by 79 to yes.
start. evol. flt. dead time	After the 3-pole trip command to clear up the fault, the automatic reclosing function starts a new 3-pole automatic reclosing function cycle with the set Dead time aft. evolv. fault.

NOTE

With the use of an internal or external circuit-breaker failure protection at the same line branch, observe the following:

- The start supervision time should be the same as the circuit-breaker failure protection time delay. With this, you can make sure that in the case of a circuit-breaker failure followed by the tripping of the busbar, no automatic reclosing will be executed.
(Note: An exception to this recommendation is described below.)
- During a 1-pole or a combined tripping caused by the circuit-breaker failure protection, the start supervision time must be longer than the delay time for the 1-pole trip command repeat. With this, you can make sure that the trip command is not converted before the 1-pole trip command repeat through the circuit-breaker failure protection from the trip command synchronization of the 3-pole automatic reclosing function.
- The start supervision time must no longer than the time delay for the tripping of the busbar if a 1-pole trip command for the line branch should not be caused by the automatic reclosing function or the circuit-breaker failure protection 3-pole before the circuit-breaker failure protection can trip the busbar. With this case, the automatic reclosing function must be blocked with the trip command for the busbar. This helps to avoid an automatic reclosing function being executed after the tripping of the busbar for the line branch. The blocking of the automatic reclosing function can occur with a CFC logic to the binary input >Block function.

Parameter: CB ready superv. time

The setting of this parameter is only important if the cycle-specific parameter CB ready check bef.close is set to yes. Otherwise, this parameter has no effect.

- Default setting (_:6601:106) CB ready superv. time = 3.00 s

With the CB ready superv. time parameter, you can determine after which maximum time after the tripping the circuit breaker must be ready for the reclosing function.

Set the time somewhat longer than the regeneration time of the circuit breaker after an OFF-ON-OFF cycle.

Detailed information about the function can be found in Chapters 7.2.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition and 7.2.4.14 Closing Indication and Close Command.

Parameter: 3-pole operate by 79

This parameter is irrelevant and cannot be set if the circuit breaker is configured exclusively for 3-pole tripping.

- Recommended setting value (_:6601:107) 3-pole operate by 79 = yes

With the 3-pole operate by 79 parameter, you can determine if the automatic reclosing function creates a 3-pole operate indication to the 3-pole coupling of the circuit-breaker pole.

Parameter Value	Description
yes	The automatic reclosing function can create a 3-pole operate indication under the following conditions: • With the blocking of the automatic reclosing function in the 1-pole dead time, for example, through an evolving fault or external blocking • If an automatic reclosing function start is signaled with 2-pole tripping, for example, through external binary inputs • For operating modes with tripping, if there is a 1-pole operate indication and the automatic reclosing function does not allow for 1-pole cycles in accordance with their parameterization. • If during a 1-pole the automatic reclosing function cycle the supervision of the circuit-breaker pole recognizes an impossible condition. Siemens recommends using this setting.
no	The automatic reclosing function does not create 3-pole tripping.

Parameter Value	Description
yes	The automatic reclosing function checks the readiness of the circuit breaker for a switching cycle, consisting of a tripping reclosing switching. If the circuit breaker is ready – signaled through a binary input – the startup of the automatic reclosing function can occur. If the circuit breaker is not ready, the automatic reclosing function reports the static blocking. Siemens recommends using this setting. Note, the presetting of this parameter does not correspond with the recommended setting for operation. The automatic reclosing function would either way be blocked with a non-available circuit breaker ready signal. Please set the parameter as recommended.
no	The readiness of the circuit breaker is not checked before starting the automatic reclosing function. The test also does not occur if the readiness signal from the circuit breaker is connected to a binary input on the device.

Parameter: Reclai. time aft.succ.cyc.

- Default setting (_:6601:103) Reclai. time aft.succ.cyc. = 3.00 s

With the Reclai. time aft.succ.cyc. parameter, set the time used to decide if the currently running reclosing cycle was successful or not. Detailed information about the function of the reclaim time can be found in the chapter 7.2.4.15 Reclaim Time.

The presetting for the reclaim time can be frequently maintained. In regions where thunderstorms and storms often occur, a shorter reclaim time makes sense in order to minimize the danger of the final disconnection due to sequential lightning strikes or cable spark over.

Select a long reclaim time if there is no possibility for circuit-breaker supervision with multiple automatic reclosing, for example, due to missing auxiliary contacts or lacking circuit-breaker ready information. In this case, the reclaim time must be longer than the recovery time of the circuit breaker.

Parameter: Block. time aft. man.close

- Default setting (_:6601:104) Block. time aft. man.close = 1.00 s

With the Block. time aft. man.close parameter, the time is determined for which the automatic reclosing should be blocked after a manual connection.

Set the time so that the circuit breaker can be safely switched on and off during connection to a short circuit without the automatic reclosing function being automatically closed.

Parameter: Start signal supervis.time

- Default setting (_:6601:105) Start signal supervis.time = 0.25 s

With the Start signal supervis.time parameter, set the maximum time after which a circuit breaker must be opened after a trip command. If the time expires, a failure of the circuit breaker is assumed and the automatic reclosing function is dynamically blocked.

Detailed information about the function of the start supervision time can be found in the chapter 7.2.4.5 Start.

Parameter: Max. dead-time delay

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting (_:6601:110) Max. dead-time delay = 0.5 s

With the Max. dead-time delay parameter, you determine at which time the starting of the dead time may be delayed before the automatic reclosing function is dynamically blocked.

The delay of the start of the dead time is possible with the binary input >Dead time start delay.

You can find detailed information about the functionality in the chapter 7.2.4.5 Start.

Parameter: Max. dead-time extension

- Default setting (_:6601:111) Max. dead-time extension = 1.2 s

With the Max. dead-time extension parameter, you determine the time by which the dead time may be extended before the automatic reclosing function is dynamically blocked.

With the setting oo (invalid), the extension is unlimited.

An extension of the dead time can be required under the following conditions:

- Waiting for the readiness of the circuit breaker
- Inquiry of a synchronous test
- Delay through binary input in order e.g. to give the leading automatic reclosing function priority in a system with 1 1/2 circuit-breaker layout.

Remember that longer dead times after 3-pole disconnection are only permissible if no stability problems occur or if a synchronous test occurs before the reclosing.

You can find detailed information about the functionality in the chapter 7.2.4.14 Closing Indication and Close Command.

Parameter: Voltage supervision time

This parameter is only important if you use the subfunctions RDT, DLC, or the ADT function. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting (_:6601:114) Voltage supervision time = 0.1 s

With the Voltage supervision time parameter, you can determine the measuring time that is available as a criteria for the voltage decision. It should be longer than all transient oscillations through switching operations.

For the subfunctions Reduced dead time and Reclosing function with adaptive dead time, the measuring time applies for the determination of the surpassing of a voltage threshold. For the subfunction Dead-line check, the surpassing of a voltage threshold is checked.

Siemens recommends the setting 0.10 s.

Detailed information about the functionality can be found in the following parameters and in the chapters 7.2.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT) and 7.2.5.1 Description.

Parameter: Volt. thres.f. live line/bus

This parameter is only important if you use the subfunction RDT or the function ADT. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting (_:6601:115) Volt. thres.f. live line/bus = 48 V

With the Volt. thres.f. live line/bus parameter, you can determine the limit voltage above which the line should be seen as fault-free. It must be lower than the smallest expected operating voltage. The phase-to-ground voltage applies as the reference value.

Detailed information about the functionality can be found in the following settings and in the chapters 7.2.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT) and 7.2.5.1 Description.

Parameter: Dead-line check/reduc.d.t.

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting (_:6601:113) Dead-line check/reduc.d.t = without

With the Dead-line check/reduc.d.t parameter, you can determine if the automatic reclosing function should work with one of the additional functions Dead-line check DLC or Reduced dead t. RDT.

Parameter Value	Description
without	The automatic reclosing function occurs after the expiration of the parameterized dead times. DLC or RDT are not activated.
Reduced dead t. RDT	The automatic reclosing function works with a reduced dead time (RDT).
Dead-line check DLC	The automatic reclosing functions works with dead line check. The closing indication is only assigned if the line was really de-energized during the dead time.

You can find detailed information about the functionality in the chapter 7.2.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT).

NOTE

Use RDT or DLC only if the voltages of the line can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line side – seen from the circuit breaker.

Parameter: Volt.thres. f. dead line/bus

This parameter is only important if you use the Dead-line check subfunction. If you do not use any of this subfunction, the setting of this parameter is free to select.

- Default setting (_:6601:116) Volt.thres. f. dead line/bus = 30 V

With the Volt.thres. f. dead line/bus parameter, you can determine the limit voltage below which the line should be seen with certainty as idle or switched off. The threshold value is used by the Dead-line check subfunction (dead line check). The reference size is the phase to ground voltage.

You can find detailed information about the functionality in the chapter 7.2.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT).

Parameter: Send delay f. remot. close

With the Send delay f. remot. close parameter, you can determine after which time after the automatic reclosing function the information is sent to the remote stations.

- Default setting (_:6601:112) Send delay f. remot. close = oo (invalid)

The transmission delay prevents the device operating in the adaptive dead time mode on the opposite side from closing unnecessarily if the local reclosing function remains unsuccessful. On the other hand, it must be remembered that the line is not available for transporting energy as long as the opposite end is also closed. Thus, the Send delay f. remot. close must be added to the dead time in order to determine the system stability.

You can find detailed information about this functionality in the chapter 7.2.4.14 Closing Indication and Close Command.

7.2.8 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function

For the function of the cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete more cycles from the function library in DIGSI 5.

Parameter: Start from idle state allow.

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode with action time.

- Default setting (_:6571:102) Start from idle state allow. = yes

With the parameter Start from idle state allow. you can determine whether the action time of this automatic reclosing cycle is started, if the automatic reclosing function is in idle state dealing with incoming general pickup. Please set the parameter always to yes, if the automatic reclosing function is configured for only 1 cycle. If several cycles are configured, you can control the effectiveness of the automatic reclosing cycles with this parameter and various action times.

Detailed information about the functionality can be found in Chapters 7.2.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time and 7.2.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time.

Parameter: Action time

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode with action time.

- Default setting (_:6571:103) Action time = 0.2 s

With this parameter Action time you can determine, within which time frame the trip command must appear, in order to start the automatic reclosing function. If the trip command occurs only after the action time has expired, automatic reclosing does not occur within the active automatic reclosing cycle.

You can find detailed information about the functionality in Chapters 7.2.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time and 7.2.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time.

Parameter: Dead time aft. 3-pole trip

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode with tripping.

- Default setting (_:6571:109) Dead time aft. 3-pole trip = 0.5 s

With this parameter Dead time aft. 3-pole trip, you can determine after which dead time the automatic reclosing function will be executed. After a 3-pole trip of the circuit breaker, the system stability is priority. Since the switched off line cannot develop synchronizing forces, only a short dead time is permitted in most cases. The usual duration is 0.3 s to 0.6 s. A longer period can be tolerated if a synchrocheck is carried out prior to reclosing. Longer 3-pole dead times are also possible in radial systems.

Parameter: Dead time aft.1ph. pickup, Dead time aft.2ph. pickup, Dead time aft.3ph. pickup

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode with pickup.

- Default setting (_:6571:104) Dead time aft.1ph. pickup = 1.2 s
- Default setting (_:6571:105) Dead time aft.2ph. pickup = 1.2 s
- Default setting (_:6571:106) Dead time aft.3ph. pickup = 0.5 s

With the 3 dead time parameters, you can determine after which dead time the automatic reclosing function will be executed. Please set the times as desired for the respective type of short circuit.

- The parameter Dead time aft.1ph. pickup applies to dead times after 1-phase short circuits and the following protection tripping: A, B, C, or A-Gnd, B-Gnd, C-Gnd
- The parameter Dead time aft.2ph. pickup applies to dead times after 2-phase short circuits and the following protection tripping: A-B, B-C, C-A, or A-B-Gnd, B-C-Gnd, C-A-Gnd
- The parameter Dead time aft.3ph. pickup applies to dead times after 3-phase short circuits and the following protective tripping: A-B-C or A-B-C-Gnd

NOTE

If you would like to avoid automatic reclosing during individual short-circuit types, please set the respective dead times to oo (invalid).

Example:

After 1-phase short-circuits, the automatic reclosing function should occur after 1.2 s. The automatic reclosing function should not occur for 2-phase and 3-phase short circuits.

For this application, the parameters should be set as follows:

- Dead time aft.1ph. pickup = 1.2 s
- Dead time aft.2ph. pickup = oo (invalid)
- Dead time aft.3ph. pickup = oo (invalid)

Parameter: Dead time aft. evolv. fault

These parameters are only significant if the parameter (_:6601:109) Response to evolv. faults is set to start evol.flt dead time.

- Default setting (_:6571:109) Dead time aft. evolv. fault = 1.2 s

With the parameter Dead time aft. evolv. fault, you can determine after which dead time the automatic reclosing function should be operated, if based on an evolving fault during the current dead time, a 3-pole trip has occurred. For this 3-pole dead time, stability concerns for the system are also important. Often, this dead time as well as the parameter (_:6571:108) Dead time aft. 3-pole trip can be set.

Detailed information about the function during evolving faults during dead time are described in Chapter 7.2.4.13 Evolving Fault Detection During Dead Time.

Parameter: CB ready check bef.close

- Default setting (_:6571:111) CB ready check bef.close = no

With the parameter CB ready check bef.close you can determine if after the expiration of the dead time (meaning, directly prior to assigning the close command) readiness of the circuit breaker should be queried.

Parameter Value	Description
no	With the setting no, the automatic reclosing function does not check again the readiness of the circuit breaker prior to assigning the close command. Siemens recommends this setting, if it is sufficient to ensure the readiness of the circuit breaker for the entire switching cycle once before the start of a reclosing function, consisting of tripping reclosing tripping. The setting for checking the readiness of the circuit breaker prior to the start of the automatic reclosing function is done using the parameter (_:6601:107) CB ready check bef. start.
yes	With the setting yes, the dead time can be extended if after the expiration of the dead time the circuit breaker is not ready for the next ON-OFF cycle. The maximum delay of the dead time can be set with the parameter (_:6601:111) Max. dead-time extension. Siemens recommends this setting, if it can be assumed that the circuit breaker becomes available to switch on the reclosing function only after an additional waiting period.

Detailed information about the function can be found in Chapter 7.2.4.16 Circuit-Breaker Readiness and Circuit-Breaker Condition and 7.2.4.11 Closing Indication and Close Command.

Parameter: Synchrock. aft. 3-pole d.t.

- Default setting (_:6571:110) Synchrock. aft. 3-pole d.t. = none

With the parameter Synchrock. aft. 3-pole d.t. you can determine if a synchrocheck must be carried out for the configured automatic reclosing cycle.

If during a 3-pole interruption in the system stability problems may be a concern, the synchrocheck should be carried out. If only 1-pole reclosing cycles are possible or stability problems are not to be expected during the 3-pole dead time, for example, due to a highly intermeshed system or radial system, please select the parameter none.

Parameter Value	Description
none	During the automatic reclosing cycle a synchrocheck is not executed.
internal	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. For the synchrocheck a synchrocheck stage of the internal synchronization function is used, which is contained in the same function group as the circuit breaker and the automatic reclosing function. The selection of the synchrocheck stage that is used in the automatic reclosing cycle occurs through the following described parameter Internal synchrocheck.
external	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. An external synchrocheck device initiates the synchrocheck. The external synchrocheck device is connected with the binary signals >Synchrocheck request and >Release by ext.sync.. Detailed information about the function can be found in Chapter 7.2.4.11 Closing Indication and Close Command under the section Synchrocheck.

Parameter: Internal Synchrocheck

These parameters are only significant if the previously described parameter (_:6571:110) Synchrock. aft. 3-pole d.t. is set to internal.

With the parameter Internal Synchrocheck, you can determine which function block of the synchronization function for the automatic reclosing function is used after a 3-pole dead time. This selection is only possible for function blocks of the synchronization function, and which are included in the same circuit-breaker function group as the automatic reclosing function. The setting options of the parameter will be generated dynamically, according to the actual parameterization.

7.2.9 Information List

No.	Information	Data Class (Type)	Type
Ext			
_:6661:51	ExtMode (controllable)		C
_:6661:501	Ext:>Release stages		I
_:6661:502	Ext:>1-pole trip permitted		I
_:6661:503	Ext:>1-pole AR only		I
_:6661:52	Ext:Behavior		O
_:6661:53	Ext:Health		O
_:6661:54	Ext:Inactive		O

7.3 External Trip Initiation 3-Pole

7.3.1 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

7.3.2 Structure of the Function

The External trip initiation function contains one step. The External trip initiation function can be instantiated in FG [illegible] multiple times.

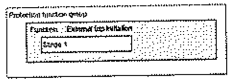


Figure 7-48 Structure/Embedding of the Function

7.3.3 Stage Description

Logic of the Stage

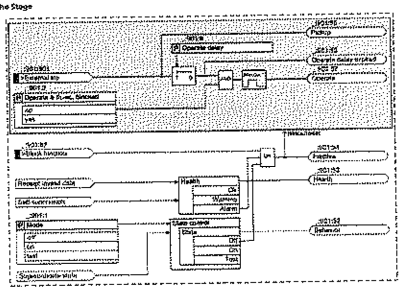


Figure 7-49 Logic Diagram for the External Trip Initiation Stage

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.

7.3.4 Application and Setting Notes

7.3.5 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

7.3.6 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:901:82	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

7.4 Overcurrent Protection, Phases

7.4.1 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

7.4.2 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)

Only the Advanced function type is available in the bay controllers. 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

298

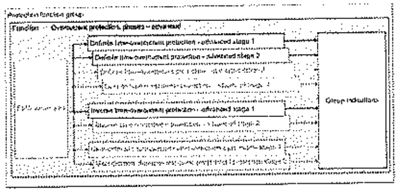


Figure 7-50 Structure/Embedding of the Function Overcurrent Protection, Phases – Advanced

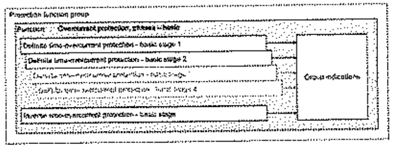


Figure 7-51 Structure/Embedding the Function Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and 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 an inrush-current detection function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

7.4.3 Filter for RMS Value Gain

7.4.3.1 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

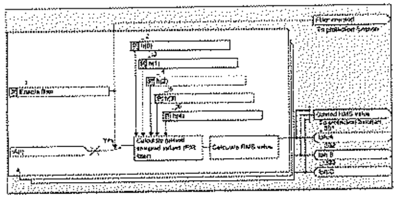


Figure 7-52 Logic Diagram of the Function Block Filter

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 this 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 FB 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 ---.

7.4.3.2 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 in 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) = -0.119 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

7.4.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filter				
_: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

7.4.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O

7.4.4 Stage with Definite-Time Characteristic Curve

7.4.4.1 Description

Logic of the Basic Stage

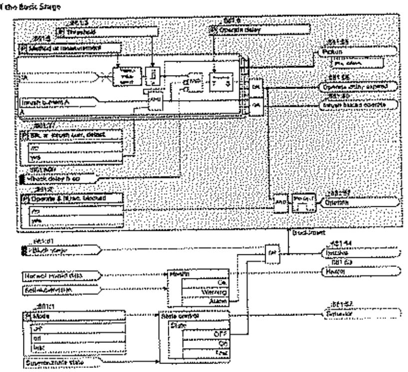


Figure 7-53 Logic Diagram of the Definite-Time Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage

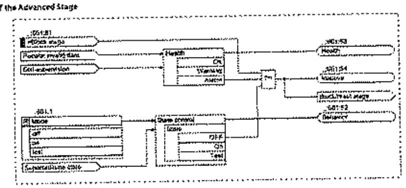


Figure 7-54 Logic Diagram of the Stage Control

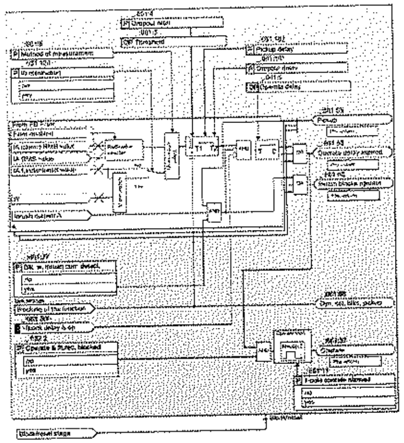


Figure 7-55 Logic Diagram of the Definite-Time Overcurrent Protection (Phases) – Advanced

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_N must be measured.

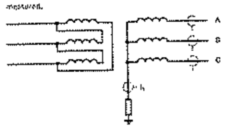


Figure 7-56 I0 Elimination Principle

In case of an I0 elimination, the following calculations result:

$I_{A\,elim.} = I_A - 1/3\, I_N$

$I_{B\,elim.} = I_B - 1/3\, I_N$

$I_{C\,elim.} = I_C - 1/3\, I_N$

The phase current $I_{ph\,elim.}$ 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 $I_{ph\,elim.}$ 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 input quality of the dynamic settings (only available in the Advanced function type, see subtitle Influence of other functions via dynamic settings and chapter 7.4.6.1 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 take 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 7.4.7.1 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
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 7.4.6.1 Description.

7.4.4.2 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.
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 (_: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 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)	$= 1.1 \cdot 630\ A = 693\ A$
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_0/Z_1 = 2

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

$$Z_L = 0.46\ \Omega/km \cdot 60\ km = 27.6\ \Omega$$

$$Z_P = \frac{110\ kV^2}{2500\ MVA} = 4.84\ \Omega$$

The 3-phase short-circuit current at the end of the line is $I_{sc\,end}$:

$$I_{sc\,end} = \frac{1.1 \cdot V_{rated}}{\sqrt{3} \cdot (Z_P + Z_L)} = \frac{1.1 \cdot 110\ kV}{\sqrt{3} \cdot (4.84\ \Omega + 27.6\ \Omega)} = 2150\ A$$

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)	$= 1.1 \cdot 2150\ A = 2365\ A$
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 (_:661:170) 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 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 0.00 s as a default.

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 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 (generated in the tripping logic of the function group Circuit-breaker) is always 3-pole because the device does not support phase-selective tripping.

7.4.4.3 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.
_:661:170	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

Addr.	Parameter	C	Setting Options	Default Setting
_:661:31	Definite-T 1:Stage blocked		• no • yes	no
Dyn. set: AR cycle 1				
_:661:28	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:661:35	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
_:661:98	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
_: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. set: 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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

7.4.4.4 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			
_: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

No.	Information	Data Class (Type)	Type
_: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. ARcycle>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:Del.Iph	WYE	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. ARcycle>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:Del.Iph	WYE	O

7.4.5 Stage with Inverse-Time Characteristic Curve

7.4.5.1 Description

Logic of the Basic Stage

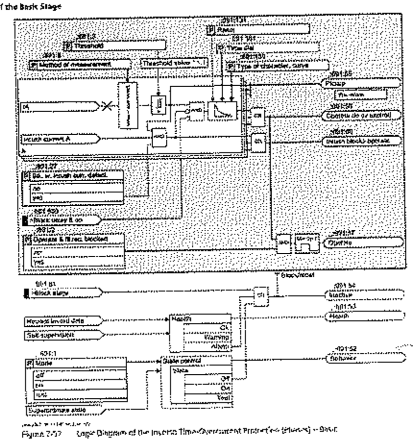


Figure 7-57 Logic Diagram of the Inverse Time-Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage

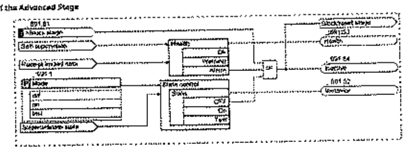


Figure 7-58 Logic Diagram of the Stage Control

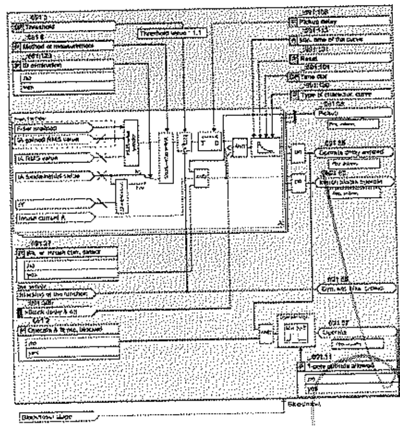


Figure 7-59 Logic Diagram of the Inverse Time-Overcurrent Protection (Phases) – Advanced

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 _:661:_:Filter enabled to yes, 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 × 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.

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.

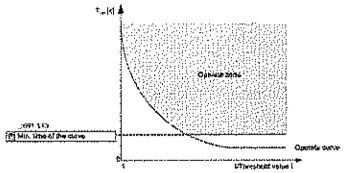


Figure 7-60 Minimum Operating Time of the Curve

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 faults on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection applications on one transformer.

In order to determine the I0 elimination of the phase currents, the transformer neutral-point current I_N must be measured.

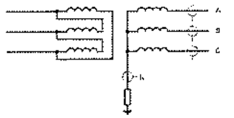


Figure 7-61 I0 Elimination Principle

In case of an I0 elimination, the following calculations must be considered:

$I_{A elim.} = I_A - 1/3 I_N$

$I_{B elim.} = I_B - 1/3 I_N$

$I_{C elim.} = I_C - 1/3 I_N$

The phase current $I_{A,B,C elim.}$ 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 $I_{A,B,C elim.}$ 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 7.4.8.1 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 7.4.7.1 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
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 7.4.8.1 Description.

7.4.5.2 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

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 11.9 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.

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 (_:691:115) 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 time.

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

Corresponding

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) = $\frac{630 \text{ A}}{600 \text{ A}} \cdot 5 \text{ A} = 5.25 \text{ A}$

[illegible]

Parameter: I0 elimination

- Default setting (_:691:120) 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 at 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 is measured and 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 (_:691:102) 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 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 trigger if the current threshold is exceeded.

For all short-circuit protection applications, this 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 (operate in the tripping logic of the function group Circuit breaker) is always 3-pole because the device does not support phase-selective tripping.

7.4.5.3 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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.set: 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
_:691:107	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
_:691:108	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

302

Addr.	Parameter	C	Setting Options	Default Setting
_: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
_: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

7.4.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation freq. mode	SPS	I
_:2311:300	General:Frequency 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:Del.Iph	WYE	O

7.4.6 Stage with User-Defined Characteristic Curve

7.4.6.1 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 7.4.5.1 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.

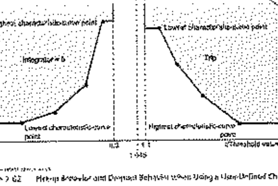


Figure 7-62 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

> **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.

7.4.6.2 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 is defined in the tripping logic of the function group Circuit breaker is always 3-pole because the device does not support phase-selective tripping.

7.4.6.3 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

Addr.	Parameter	C	Setting Options	Default Setting
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:DS - w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:120	User curve #:[illegible] elimination		• 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.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	1,500 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

Addr.	Parameter	C	Setting Options	Default Setting
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.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	1,500 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
_: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

7.4.6.4 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

7.4.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

7.4.7.1 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 11.16 Inrush-Current Detection) is in effect can the blocking be set.

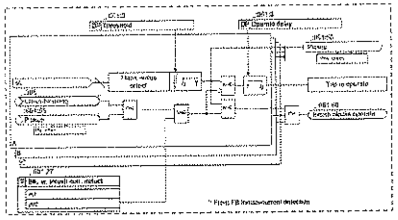


Figure 7-63 Part Logic Diagram on the Influence of Inrush Current Detection Exemplified by the 1st Definite Time Overcurrent Protection Stage

7.4.7.2 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_k 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.

7.4.8 Influence of Other Functions via Dynamic Settings

7.4.8.1 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 7-64). Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.

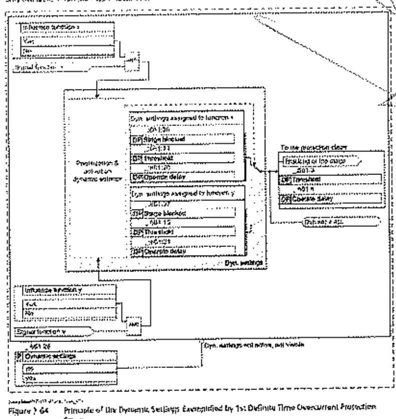


Figure 7-64 Principle of the Dynamic Settings Exemplified by 1st Definite Time Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

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.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 2 precedes that of priority 3. The settings assigned to signal 2 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 *Automatic Reclosing (Advanced Stage)*

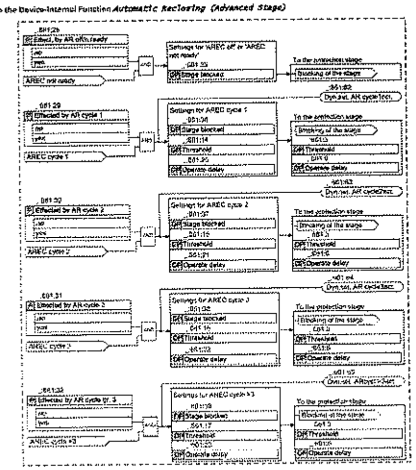


Figure 7-65 Influence of the AREC Signals on the Overcurrent-Protection Stage

Several AREC signals can affect the setting for the Threshold and Operate delay parameters of the protection stage and its blocking.

- AREC is ready for reclosing 1 (= Automatic reclosing cycle 1)
- AREC is ready for reclosing 2 (= Automatic reclosing cycle 2)
- AREC is ready for reclosing 3 (= Automatic reclosing cycle 3)
- AREC is ready for reclosing 4 (= Automatic reclosing cycle >3)

The following signal can only block the protection stage:

- AREC is not ready or switched off (= Automatic reclosing off / not ready)

This means that if the AREC is ready and the protection stage is in the idle state, the settings for AREC cycle 1 are active and not the standard settings. The standard settings are active in the case of AREC off/not ready.

The influence can be activated for each signal individually. You also have to set the Threshold and Operate delay or Stage blocked parameters, which take effect when the signal is active.

The way AREC signals are generated is described in chapter [illegible] Overview of Functions.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*

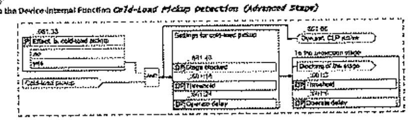


Figure 7-66 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

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 [illegible] Overview of Functions.

Link to an External Function via a Binary Input Signal (Advanced Stage)

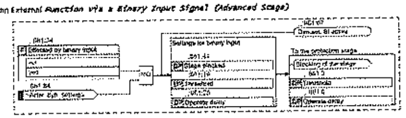


Figure 7-67 Influence of the Binary Input on the Overcurrent-Protection Stage

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.

7.4.8.2 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.
yes	If a device-internal function (automatic reclosing function 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 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 AREC

The example of how the overcurrent stage (1st stage) can be used as a fast stage before automatic reclosing describes the influence exerted by AREC.

The setting of the overcurrent stage (1st stage) results from the time-grading schedule. Additionally, it is to be used as fast stage before an automatic reclosing. Because a fast disconnection of the short-circuit current takes priority over the selectivity prior to reclosing, the tripping delay can be set to 0 or a very small value. To achieve the selectivity, the final disconnection must be done with the grading time.

AREC is set to 2 reclosings. A secondary Threshold of 1.5 A and a Operate delay of 600 ms are assumed (according to the time grading schedule) for the overcurrent-protection stage. The standard settings of the stage are set to these values.

To realize the application, the configuration settings Effected by AR cycle 1 and Effected by AR cycle 2 are changed in the example to yes (= influenced). This activates the AR cycle 1 and AR cycle 2 input signals within the stage. When they become active, they switch to the assigned dynamic settings.

The two dynamic settings Operate delay assigned to these input signals (sources of influence) are set to the time delay 0 (instantaneous tripping). The two dynamic settings Threshold assigned to these input signals are set to the normal threshold value of 1.5 A.

If the threshold value (1.5 A) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of 600 ms according to the time grading schedule.

Influence of External Devices

The influence of an external device can also be configured. The above is an example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing, in which case the AREC function is performed by an external device.

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. The external device must provide the Cycle 1 and Cycle 2 signals or, alternatively, the AR ready signal. The signals must be connected with the binary input signal >Activ. dyn. settings.

The dynamic setting Operate delay, which is assigned to the input signal (source of influence) >Activ. dyn. settings, is set to the time delay 0 (instantaneous tripping). The dynamic setting Threshold assigned to this input signal is set to the normal threshold value of 1.5 A.

If the threshold value (1.5 A) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of 600 ms according to the time grading schedule.

304

7.5 Overcurrent Protection, Ground

7.5.1 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

7.5.2 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)

Only the function type Advanced is available in the bay controllers. 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 7-68 and chapter 7.5.3.1 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

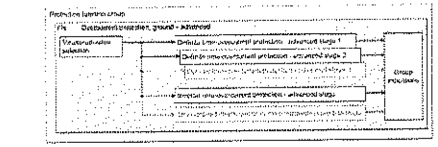


Figure 7-68 Structure/Embedding the Function Overcurrent Protection, Ground – Advanced

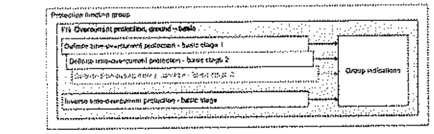


Figure 7-69 Structure/Embedding the Function Overcurrent Protection, Ground – Basic

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.
- Automatic reclosing (AREC)
- 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).

7.5.3 General Functionality

7.5.3.1 Description

Measured-Value Selection

The function provides the option to select between the values *IN measured* or *3I0 calculated*.

Figure 7-70 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 7-3 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 * 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	0.030 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 * 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

7.5.3.2 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

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.

7.5.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured

7.5.4 Stage with Definite-Time Characteristic Curve

7.5.4.1 Description

Logic of the Basic Stage

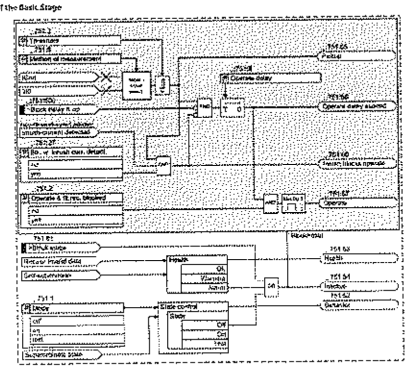


Figure 7-71 Logic Diagram of the Definite Time-Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage

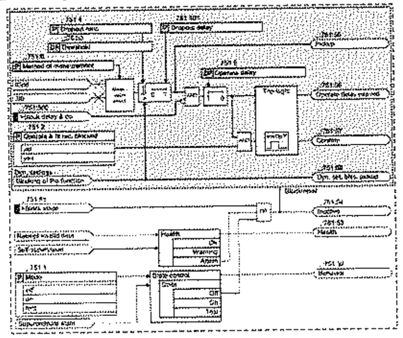


Figure 7-72 Logic Diagram of the Definite Time-Overcurrent Protection (Ground) – Advanced

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.

305

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 2.5.8.1 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 7.5.2.2 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
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 2.5.8.1 Description.

7.5.4.2 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 $0.1\ I_{rated}$.

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. When 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: $Z_{0L}/Z_{1L} = 4$

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: $Z_{0P}/Z_{1P} = 2$

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

$$Z_L = 0.46\ \Omega/\text{km} \cdot 60\ \text{km} = 27.6\ \Omega$$

$$Z_P = \frac{110\ \text{kV}^2}{2500\ \text{MVA}} = 4.84\ \Omega$$

The 1-pole short-circuit current at the end of the line is $I_{k,end,min}$:

$$I_{k,end,min} = \frac{1.1 \cdot V_N \cdot 3}{\sqrt{3} \cdot \left[Z_P \cdot \left(2 + \frac{Z_{0P}}{Z_{1P}}\right) + Z_L \cdot \left(2 + \frac{Z_{0L}}{Z_{1L}}\right)\right]} = \frac{1.1 \cdot 110\ \text{kV} \cdot 3}{\sqrt{3} \cdot [4.84\ \Omega \cdot (2 + 2) + 27.6\ \Omega \cdot (2 + 4)]} = 1133\ \text{A}$$

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

$$\text{Threshold value 2nd stage (secondary)} = 1.1 \cdot \frac{1133\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 10.39\ \text{A}$$

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 approaches 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.

7.5.4.3 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	0.030 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
_:751:4	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

Addr.	Parameter	C	Setting Options	Default Setting
_:751:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
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:Affected 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:Affected 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:Affected 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:Affected by AR cycle gr. 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:751:39	Definite-T 1:Stage blocked		• no • yes	no
_: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	0.40 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:Affected 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:Affected 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:Affected 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
_:752:27	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:Influenced 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

7.5.4.4 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
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

7.5.5 Stage with Inverse-Time Characteristic Curve

7.5.5.1 Description

Logic of the Basic Stage

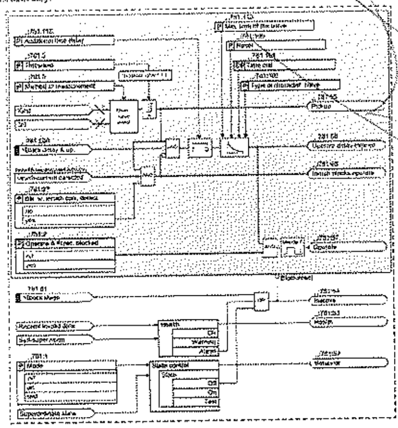


Figure 7-73 Logic Diagram of the Inverse-Time Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage

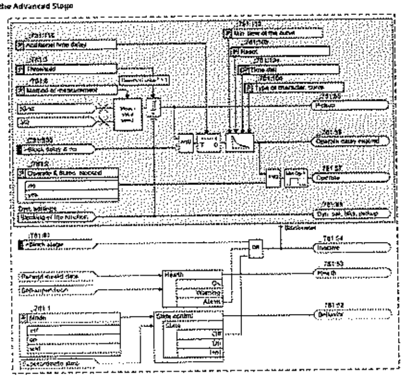


Figure 7-74 Logic Diagram of the Inverse-Time Overcurrent Protection (Ground) – Advanced

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 × 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.

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.

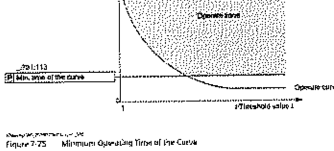


Figure 7-75 Minimum Operating Time of the Curve

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.

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 7.5.[illegible] 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 7.5.[illegible] 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
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 7.[illegible] 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 7.[illegible] Description.

7.5.5.2 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 $0.1 I_{rated,sec}$

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 1.[illegible] 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 complex schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

307

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 recommends 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.

7.5.5.3 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				
_:781:1	Inverse-T 1:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:781:27	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.rdy				
_: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.s: 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

Addr.	Parameter	C	Setting Options	Default Setting
_:781:19	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
_:781:107	Inverse-T 1:Time dial		0,00 to 15,00	1,00

7.5.5.4 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

7.5.6 Stage with User-Defined Characteristic Curve

7.5.6.1 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 7.5.5.1 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.

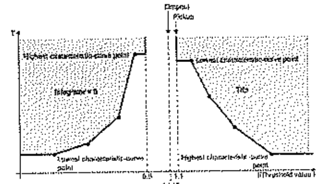


Figure 7-76 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

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.

7.5.6.2 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 7.5.5.2 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.

7.5.6.3 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 #:Stage blocked		• no • yes	no
_24	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
_116	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

7.5.6.4 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

7.5.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

7.5.7.1 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 11.16 Inrush-Current Detection) is in effect can the blocking be set.

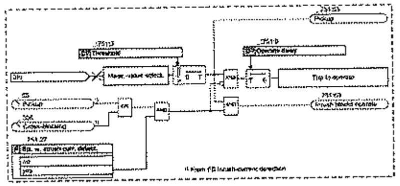


Figure 7-77 Part Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite Time-Overcurrent Protection Stage

7.5.7.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:751:127) 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.

7.5.8 Influence of Other Functions via Dynamic Settings

7.5.8.1 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.

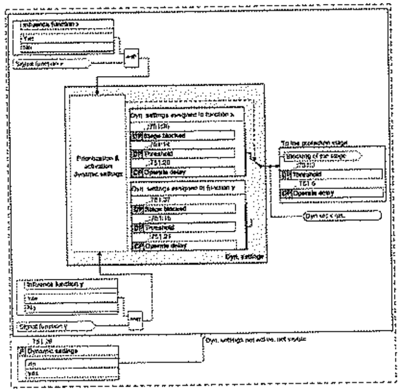


Figure 7-78 Principle of the Dynamic Settings in the Example of 1st Definite Time-Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent protection stages:

Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

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.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 2 precedes that of priority 3. The settings assigned to signal 2 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 *Automatic Reclosing (Advanced Stage)*

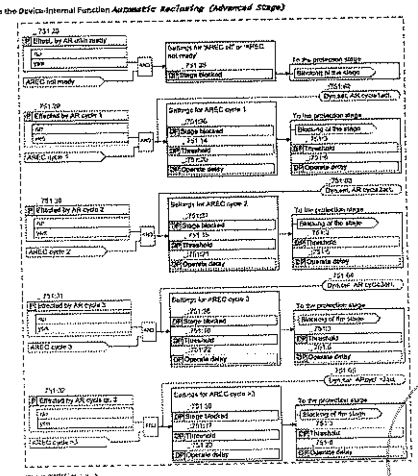


Figure 7-79 Influence of the AREC Signals on the Overcurrent-Protection Stage

Several ARFC signals can affect the setting for the Threshold and the Operate delay of the protection stage and its blocking:

- ARFC is ready for reclosing 1 (= Automatic reclosing cycle 1)
- ARFC is ready for reclosing 2 (= Automatic reclosing cycle 2)
- ARFC is ready for reclosing 3 (= Automatic reclosing cycle 3)
- ARFC is ready for reclosing 4 (= Automatic reclosing cycle >3)

The following signal can only block the protection stage:

- ARFC is not ready or switched off (= Automatic reclosing off / not ready)

This means that if the ARFC is ready and the protection stage is in the idle state, the settings for ARFC cycle 1 are active and not the standard settings. The standard settings are active in the case of ARFC off/not ready.

The influence can be activated for each signal individually. You also have to set the Threshold and Operate delay or Stage blocked parameters, which take effect when the signal is active.

The way ARFC signals are generated is described in chapter 7.7.1 Overview of Functions.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*

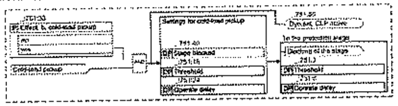


Figure 7-80 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

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 5.7.2 Cold-Load Pickup Detection (Optional).

Link to an External *Function via a Binary Input Signal (Advanced Stage)*

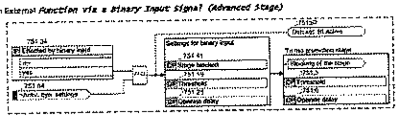


Figure 7-81 Influence of the Binary Input on the Overcurrent-Protection Stage

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.

7.5.8.2 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.
yes	If a device-internal function (automatic reclosing function 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 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 ARFC

The example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing describes the influence exerted by ARFC.

The setting of the overcurrent level (1st stage) results from the time-grading schedule. It is to be used as fast stage before an automatic reclosing. Because fast disconnection of the short-circuit current takes priority over the selectivity prior to reclosing, the Operate delay parameter can be set to 0 or to a very low value. To achieve the selectivity, the final disconnection must be done with the grading time.

ARFC is set to 2 reclosings. A secondary Threshold of 1.5 A and a Operate delay of 600 ms are assumed (according to the time-grading schedule) for the overcurrent-protection stage. The standard settings of the stage are set to these values.

To realize the application, the configuration settings Effected by AR cycle 1 and Effected by AR cycle 2 are changed in the example to yes (= influenced). This activates the AR cycle 1 and AR cycle 2 input signals within the stage. When they become active, they switch to the assigned dynamic settings.

The two dynamic settings Operate delay assigned to these input signals (sources of influence) are set to the time delay 0 (instantaneous tripping). The two dynamic settings Threshold assigned to these input signals are set to the normal threshold value of 1.5 A.

If the threshold value (1.5 A) is exceeded before ARFC 1 and ARFC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after ARFC 2 (unsuccessful ARFC), the stage trips with the time delay of 600 ms according to the time-grading schedule.

Influence of External Devices

The influence of an external device can also be configured. The above is an example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing, in which case the ARFC function is performed by an external device.

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. The external device must provide the cycle 1 and cycle 2 signals or, alternatively, an ARFC ready signal. The signals must be connected with the binary input signal >Activ. dyn. settings.

The dynamic setting Operate delay, which is assigned to the input signal (source of influence) >Activ. dyn. settings, is set to the time delay 0 (instantaneous tripping). The dynamic setting Threshold assigned to this input signal is set to the normal threshold value of 1.5 A.

If the threshold value (1.5 A) is exceeded before ARFC 1 and ARFC 2, the overcurrent protection stage trips instantaneously. If the fault still exists after ARFC 2 (unsuccessful ARFC), the stage trips with the time delay of 600 ms according to the time grading schedule.

7.6 Directional Overcurrent Protection, Phases

7.6.1 Overview of Functions

The Directional time-overcurrent protection, phases (ANSI 67):

- Detects short circuits at electrical equipment
- Can be used as backup or emergency 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

7.6.2 Structure of the Function

7.6.3 Stage Control

7.6.3.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.

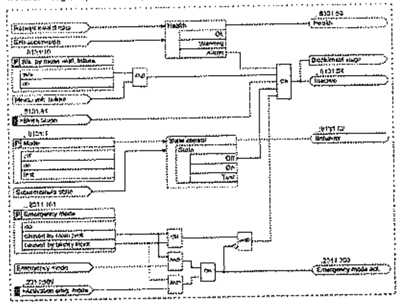


Figure 7-82 Stage-Control Logic Diagram

Emergency Mode (Advanced Stage)

You use the Emergency mode parameter to define whether the stage operates as emergency overcurrent protection or as backup overcurrent protection. With the setting Emergency mode = caused by main prot., emergency overcurrent protection starts automatically when the main protection fails. With the appropriate parameterization (Emergency mode = caused by binary input), the emergency mode can also be activated from an external source.

If the overcurrent protection is set as backup overcurrent protection (parameter Emergency mode = no), it operates independently of the main protection and thus in parallel.

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.

7.6.3.2 Application and Setting Notes

Parameter: Blk. by meas-volt. failure

- Recommended setting value (_:8131:10) 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.

7.6.4 Stage with Definite-Time Characteristic Curve

7.6.4.1 Description

Logic of the Basic Stage

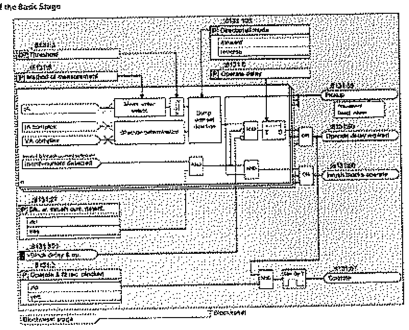


Figure 7-83 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage

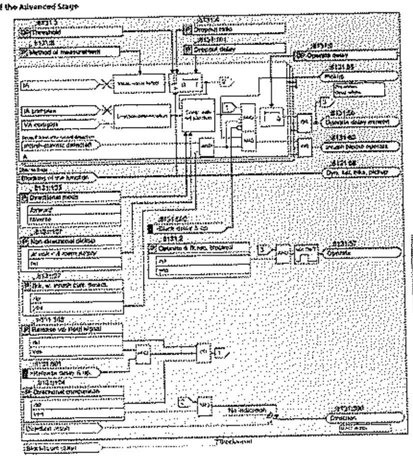


Figure 7-84 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Advanced

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 7.6.7.2 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 7.6.7.2 Description), if no voltage measure-

310

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 set 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 7.6.3.1 Description)
- Measuring-voltage failure (see chapter 7.6.3.1 Description)
- Via the dynamic settings function (only provided in the Advanced function type, see chapter Influence of other functions via dynamic settings and chapter 7.1.6.1 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 7.4.7.1 Description.

7.6.4.2 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}.

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 7.6.10 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 in the line side 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 for a 3-phase close-up fault.

Parameter: Threshold

- Default setting (_:8131:3) Threshold = 1.500 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 7.4.4.2 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 7.6.9 Application Notes for Parallel Lines and 7.6.10 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.

7.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Momentary mode		• no • caused by main prot. • caused by binary input	no
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °

Addr.	Parameter	C	Setting Options	Default Setting
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	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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
_:8131:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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
_: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	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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.set: 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	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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
Dyn.s: 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

Addr.	Parameter	C	Setting Options	Default Setting
_:8131:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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:Affected 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	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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
_:8132:3	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.150 A to 175.000 A	10.000 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.150 A to 175.000 A	10.000 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

337

Addr.	Parameter	C	Setting Options	Default Setting
_: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	0.30 s
Dyn.set: AR off/n.rdy				
_:8132:29	Definite-T 2:Effect. by AR off/n.rdy		• no • yes	no
_:8132:27	Definite-T 2:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8132:24	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	0.150 A to 175.000 A	10.000 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.150 A to 175.000 A	10.000 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	0.150 A to 175.000 A	10.000 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.150 A to 175.000 A	10.000 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
_:8132:16	Definite-T 2:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.150 A to 175.000 A	10.000 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.150 A to 175.000 A	10.000 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

Addr.	Parameter	C	Setting Options	Default Setting
_:8132:22	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.10 s
Dyn.set: 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	0.150 A to 175.000 A	10.000 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.150 A to 175.000 A	10.000 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.set: 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	0.150 A to 175.000 A	10.000 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.150 A to 175.000 A	10.000 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	0.150 A to 175.000 A	10.000 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.150 A to 175.000 A	10.000 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

7.6.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emerg. mode	SPS	I
_:2311:501	General:>Test of direction	SPS	I
_:2311:300	General:Emergency mode act.	SPS	O

No.	Information	Data Class (Type)	Type
_: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. ARcycl.>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. ARcycl.>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
_: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

7.6.5 Stage with Inverse-Time Characteristic Curve

7.6.5.1 Description

Logic of the Basic Stage

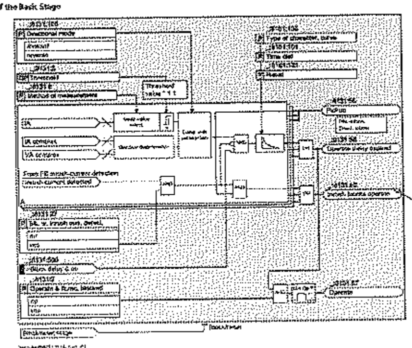


Figure 7-85 Logic Diagram of the Directional, Inverse-Time Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage

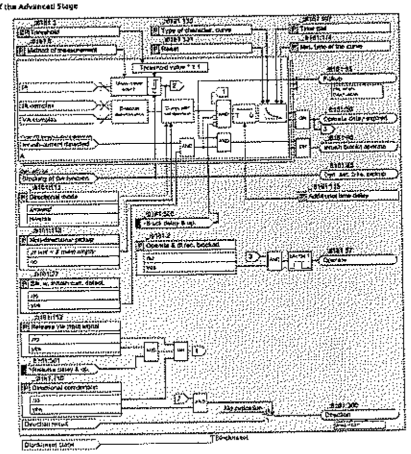


Figure 7-86 Logic Diagram of the Directional, Inverse-Time Overcurrent Protection, Phases - Advanced

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 7.6.7.1 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 7.6.7.1 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. < & 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.

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.

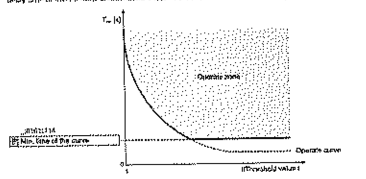


Figure 7-87 Minimum Operating Time of the Curve

312

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 7.6.3.1 Description)
- Measuring-voltage failure (see chapter 7.6.3.1 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 7.7.6.1 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 7.4.7.1 Description.

7.6.5.2 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.
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 7.6.10 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 side 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 pick up 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 at 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, this 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 at 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 7.4.5.2 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.

7.6.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Emergency mode		• no • caused by main prot. • caused by binary input	no
_:2311:102	General:Rotation angle of ref. volt.		-180° to 180°	45°
Inverse-T 1				
_: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.

Addr.	Parameter	C	Setting Options	Default Setting
_: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		0.00 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
_: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		0.00 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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		0.00 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		0.00 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		0.00 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
_: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		0.00 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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		0.00 to 15.00	1.00

7.6.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Activation emerg. mode	SPS	I
_:2311:501	General:>Test of direction	SPS	I
_:2311:400	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
_:8161:59	Inverse-T 1:Disk emulation running	SPS	O
_:8161:55	Inverse-T 1:Pickup	ACD	O
_:8161:302	Inverse-T 1:Direction	ACD	O
_:8161:56	Inverse-T 1:Operate delay expired	ACT	O
_:8161:57	Inverse-T 1:Operate	ACT	O

7.6.6 Stage with User-Defined Characteristic Curve

7.6.6.1 Description

The structure of this stage is identical to that of the advanced stage with directional inverse-time characteristic curve (7.6.4.1 Description). The only difference is that you can define the characteristic curve as desired.

343

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.

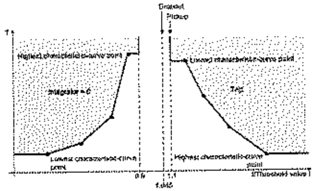


Figure 7-88 Pickup and Dropout Behavior When Using a Directional User-Defined Characteristic Curve

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.

7.6.6.2 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.

7.6.6.3 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

Addr.	Parameter	C	Setting Options	Default Setting
_:9	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Non-direc. trip at pickup		• no • at volt. & mem.empty	at volt. & mem.empty
_:108	User curve #:Directional comparison		• no • yes	no
_:113	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	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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.ready				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.sett: 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	1.500 A
		5 A @ 100 Irated	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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

Addr.	Parameter	C	Setting Options	Default Setting
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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.sett: 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	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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.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	1.500 A
		5 A @ 100 Irated	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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				
_:11	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:50	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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.sett: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.150 A to 175.000 A	7.500 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.150 A to 175.000 A	7.500 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

7.6.6.4 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. 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
_:300	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

7.6.7 Direction Determination

7.6.7.1 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 corresponding phase-to-phase voltage (as the reference voltage) to determine the direction. This means that the direc-

tion 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 7-89, 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 7-89, right).

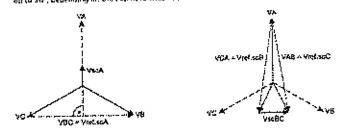


Figure 7-89 Cross Polarized Voltages for Direction Determination

The following table shows how measurands are assigned for direction-determination purposes in the event of different types of fault.

Table 7-2 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_N
A, Gnd	–	V_{BC}	–	–	–	–	I_N	V_N
B, Gnd	–	–	I_B	V_{CA}	–	–	I_N	V_N
C, Gnd	–	–	–	–	I_C	V_{AB}	I_N	V_N
A, B	I_A	V_{BC}	I_B	V_{CA}	–	–	–	–
B, C	–	–	I_B	V_{CA}	I_C	V_{AB}	–	–
A, C	I_A	V_{BC}	–	–	I_C	V_{AB}	–	–
A, B, Gnd	I_A	V_{BC}	I_B	V_{CA}	–	–	I_N	V_N
B, C, Gnd	–	–	I_B	V_{CA}	I_C	V_{AB}	I_N	V_N
A, C, Gnd	I_A	V_{BC}	–	–	I_C	V_{AB}	I_N	V_N
A, B, C	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	–	–
A, B, C, Gnd	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	I_N	V_N

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

317

failure 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 7-90 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_k. 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°.

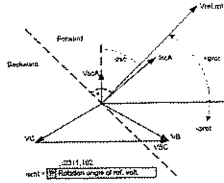


Figure 7-90 Rotation of the Reference Voltage, Phase Measuring Element

The rotated reference voltage defines the forward and reverse range; see Figure 7-91. 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.

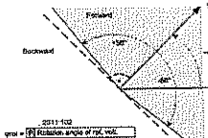


Figure 7-91 Forward Characteristic of the Directional Function, Phase-Measuring Element

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.

7.6.7.2 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 7-3). 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 fault) and 30° (close-up fault) dependent upon the collapse of the faulted voltage (see Figure 7-90). 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 7-3 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.

7.6.8 Influence of Other Functions via Dynamic Settings

The influence of these functions via dynamic settings is described in chapter 7.4.7.1 Description and chapter 7.4.8.2 Application and Setting Notes (Advanced Stage).

7.6.9 Application Notes for Parallel Lines

Parallel Lines or Transformers

In parallel lines or transformers with infeed at one end (see Figure 7-92), 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 7-92, 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 directional devices without time delay.

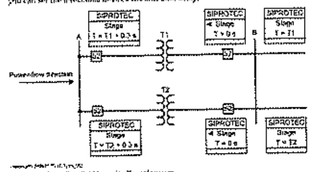


Figure 7-92 Parallel Line with Transformers

Legend for Figure 7-92

Stage ◄:	Directional stage, forward direction set
Stage:	Non-directional stage
T:	Grading time

7.6.10 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 7-93. 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.

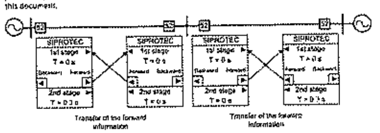


Figure 7-93 Selectivity through Directional Comparison Protection

Legend for Figure 7-93

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 protection-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, malfunction is not possible if communication is lost. Therefore, a loss of communication is not critical where the 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 is so 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 Direction 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.

7.7 Directional Overcurrent Protection, Ground

7.7.1 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 lines connected to form ring topologies

7.7.2 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 7-94 and Figure 7-95, 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 7-94 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

315

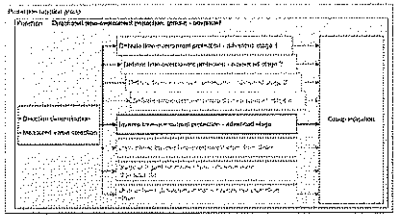


Figure 7-94 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Advanced

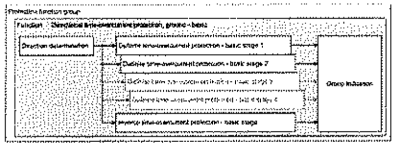


Figure 7-95 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Basic

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.

7.7.3 General Functionality

7.7.3.1 Measured Value Selection

Logic

The function provides the option to select between the values *IN measured* or *3I0 calculated*.

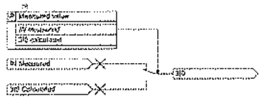


Figure 7-96 Logic Diagram of Measured-Value Selection

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 7-4 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 * 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	0.030 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 * 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

7.7.3.2 Direction Determination

Logic of Direction Determination

The following figure represents the logic of the direction determination. It applies to all types of stages.

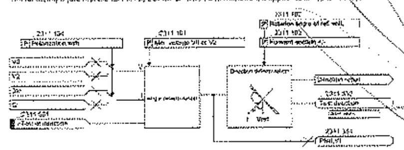


Figure 7-97 Logic Diagram of Direction Determination

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 IN (=-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.

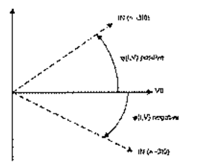


Figure 7-98 Measured-Value Definition

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 7-99 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°.

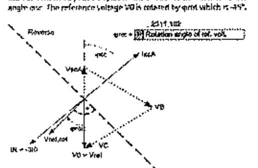


Figure 7-99 Rotation of the Reference Voltage, Directional Time-Overcurrent Protection, Ground Function with Zero-Sequence Values

The rotated reference voltage Vref, rot and the parameter Forward section +/- define the forward and reverse ranges, see Figure 7-100. 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.

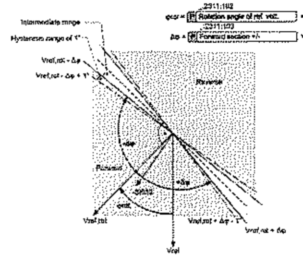


Figure 7-100 Forward/Reverse Characteristic of the Directional Time-Overcurrent Protection, Ground Function

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.

7.7.3.3 Application and Setting Notes

Parameter: Measured value

- Recommended setting value (_:9) 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.

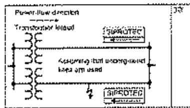
Some example settings for special applications appear below Table 7-5. Note that for 1-phase-to-ground faults (PG faults), the reference voltage is the zero-sequence voltage V0. This results in the following setting for the rotation angle:

Rotation angle of ref. volt. = -φk ground measuring elements (PG faults)

Table 7-5 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°

316

	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.

7.7.3.4 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

7.7.3.5 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

7.7.4 Stage Control

7.7.4.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.

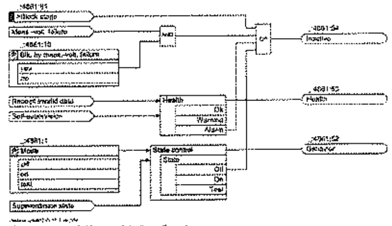


Figure 7-101 Logic Diagram of the Stage Control

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 in 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.

7.7.4.2 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 [illegible]
- 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.

7.7.5 Stage with Definite-Time Characteristic Curve

7.7.5.1 Description

Logic of the Basic Stage

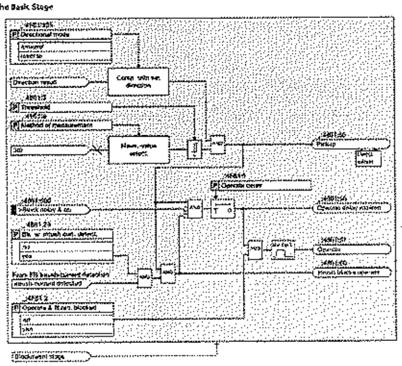


Figure 7-102 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage

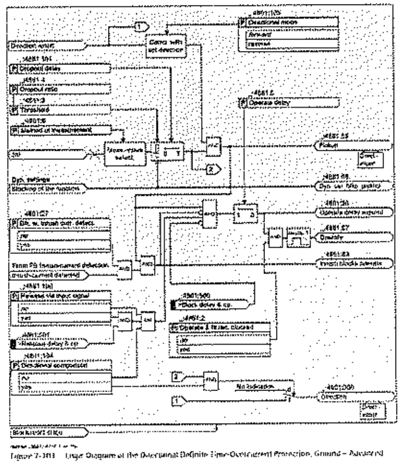


Figure 7-103 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Advanced

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 7-6 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 components 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 7.7.3.2 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 7.7.4.1 Description)
- Measuring-voltage failure (see chapter 7.7.4.1 Description)
- Via the dynamic settings functionality (only available in the advanced function type, see Influence of Other Functions via Dynamic Settings and chapter 7.7.10 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 7.7.7.1 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.

317

Directional Comparison Protection (Advanced Stage)

This 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 7.7.6.1 Influence of Other Functions via Dynamic Settings.

7.7.5.2 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 enable information from the opposite end (forward information from the Direction output signal). See also the application example in chapter 7.6.10 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 7.5.8.2 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 = 1.20 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 7.5.4.2 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 7.6.9 Application Notes for Parallel Lines and 7.6.10 Application Notes for Directional Comparison Protection.

7.7.5.3 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

7.7.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:302	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
_: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

318

7.7.6 Stage with Inverse-Time Characteristic Curve

7.7.6.1 Description

Logic of the Basic Stage

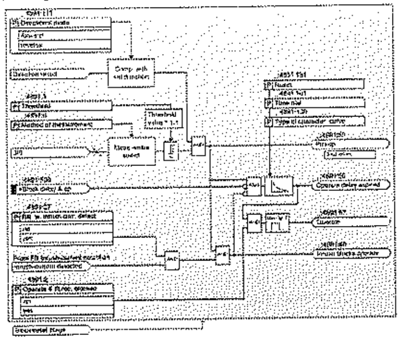


Figure 7-104 Logic Diagram of the Directional Inverse Time-Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage

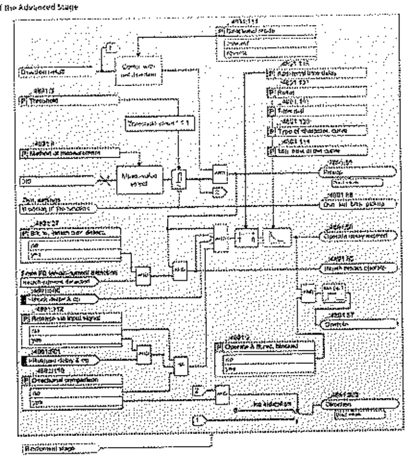


Figure 7-105 Logic Diagram of the Directional Inverse Time-Overcurrent Protection, Ground – Advanced

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 7-1 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	1 * 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-ph + IN 3-ph + 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 7.7.3.2 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 1.1 x threshold value), the dropout starts. The pickup will be indicated as clearing. You can influence the dropout behavior via settable 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.

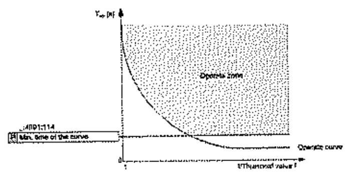


Figure 7-106 Minimum Operating Time of the Curve

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 7.7.4.1 Description)
- Measuring-voltage failure (see chapter 7.7.4.1 Description)
- Via the dynamic settings functionality (only available in the advanced function type, see Influence of Other Functions via Dynamic Settings and chapter 7.7.10 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 7.5.7.1 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 7.7.10 Influence of Other Functions via Dynamic Settings.

7.7.6.2 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 (_:4891:117) 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.

Parameter Value	Description
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 release information from the opposite end (forward information from the Direction output signal). See also the application example in chapter 7.6.10 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 affected by Auto recloser, 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 7.6.8.2 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.

319

Parameter Value	Description
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 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.

7.7.6.3 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		0.05 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.ready				
_: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 b. 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

7.7.6.4 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
_:4891:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4891:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4891:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4891:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O

No.	Information	Data Class (Type)	Type
_:4891:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:4891:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:4891:68	Inverse-T 1:Dyn. set. blks. pickup	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

7.7.7 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

7.7.7.1 Description

Logic of the Stage

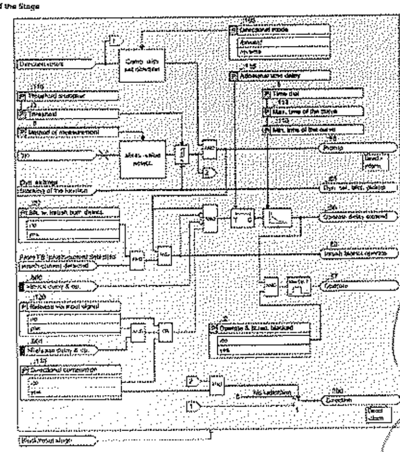


Figure 7-157 Logic Diagram of the Directional Logarithmic Inverse Time-Overcurrent Protection, Ground

Apart from the operate curve, the type of stage is identical to the inverse time-overcurrent protection – advanced stage (see chapter 7.7.6.1 Description).
This section will only discuss the nature of the operate curve. For further functionality, refer to chapter 7.7.6.1 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.

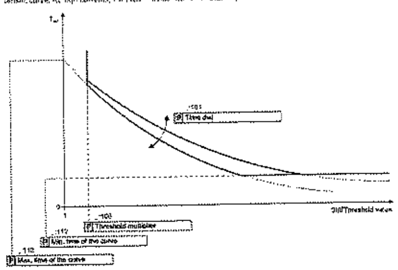


Figure 7-108 Operate Curve of Logarithmic Inverse-Time Characteristic

The time to operate is calculated with the following formula:

$$T_{op} = T_{max} - T_d \cdot \ln\left(\frac{3I0}{I_{thresh} \cdot I_{mul}}\right)$$

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.

7.7.7.2 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 7.7.6.1 Description).

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 7.7.6.2 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.

Siemens recommends setting this time to 0 s so that it has no effect.

7.7.7.3 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
_:120	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.set: 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.set: 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

Addr.	Parameter	C	Setting Options	Default Setting
_:18	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
_:111	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: bin.input				
_:34	Log. inv. T #:Effected by binary input		• no • yes	no
_:41	Log.-inv.-T #:Stage blocked		• no • yes	no
_:19	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
_:112	Log. inv. T #:Time dial		0.000 s to 60.000 s	1.250 s

7.7.7.4 Information List

No.	Information	Data Class (Type)	Type
Log.-inv.-T #			
_:81	Log. inv. T #:>Block stage		I
_:501	Log.-inv.-T #:>Release delay & op.		I
_:84	Log.-inv.-T #:>Activ. dyn. settings		I
_:500	Log.-inv.-T #:>Block delay & op.		I
_:54	Log. inv. T #:Inactive		O
_:52	Log.-inv.-T #:Behavior		O
_:53	Log.-inv.-T #:Health		O
_:60	Log.-inv.-T #:Inrush blocks operate		O
_:62	Log. inv. T #:Dyn.set. AR cycle1act.		O
_:63	Log. inv. T #:Dyn.set. AR cycle2act.		O
_:64	Log.-inv.-T #:Dyn.set. AR cycle3act.		O
_:65	Log.-inv.-T #:Dyn.set. ARcycl.>3act		O
_:66	Log.-inv.-T #:Dyn.set. CLP active		O
_:67	Log. inv. T #:Dyn.set. BI active		O
_:68	Log.-inv.-T #:Dyn. set. blks. pickup		O
_:55	Log.-inv.-T #:Pickup		O
_:300	Log.-inv.-T #:Direction		O
_:56	Log. inv. T #:Operate delay expired		O
_:57	Log. inv. T #:Operate		O

7.7.8 Stage Description Knee-Point Characteristic Curve

7.7.8.1 Description

Logic of the Stage

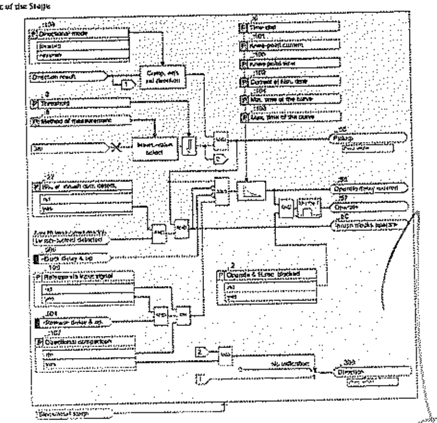


Figure 7-109 Logic Diagram of the Directional Logarithmic Inverse Time with Knee-Point Overcurrent Protection, Ground

Apart from the operate curve, this type of stage is almost identical to the inverse time-overcurrent protection – advanced stage (see chapter 7.7.6.1 Description). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 7.7.6.1 Description.

321

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 threshold 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 graphic. The curve is composed of 2 sections with different slopes. 2 parameters are used to define the logarithmic inverse time with knee point characteristic curve. The parameter Max. time of the curve determines the initial time value of the characteristic curve, and relates to the 20 Threshold value. The transition point is defined by parameter Knee-point current and parameter Knee-point time. The parameter Min. time of the curve indicates the lower time limit, and parameter Current at Min. time determines the current value at Min. time of the curve. The parameter Time dial serves as a time factor to the operate time.

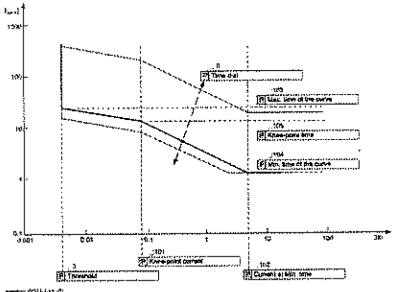


Figure 7-110 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (in the Example of Threshold = 0.004 A)

7.7.8.2 Application and Setting Notes

Apart from the operate curve, this type of stage is almost identical to the inverse time-overcurrent protection – advanced stage (see chapter 7.7.6.1 Description). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 7.7.6.2 Application and Setting Notes.

Parameter: Threshold

- Default setting (_:3) Threshold = 1.50 A

You can use the Threshold parameter to define the pickup value of the stage corresponding to the specific application.

Parameter: Time dial

- Default setting (_:6) Time dial = 0.2

You can use the Time dial parameter to displace the operate curve in the time direction.
General information cannot be provided. Define the value corresponding to the application.

Parameter: Knee-point

- Default setting (_:101) Knee-point current = 1.300 A
- Default setting (_:105) Knee-point time = 23.60 s

You use the Knee-point current parameter and the Knee-point time parameter to define the knee-point of the operate curve.
General information cannot be provided. Define the values corresponding to the application.

Parameter: Minimum Time of the Operate Curve

- Default setting (_:104) Min. time of the curve = 0.80 s
- Default setting (_:102) Current at Min. time = 1.500 A

Via the parameters Min. time of the curve and Current at Min. time, the point of the operate curve is defined where higher currents do no longer cause shorter operate times.
General information cannot be provided. Define the value corresponding to the application.

Parameter: Maximum Time of the Operate Curve

- Default setting (_:103) Max. time of the curve = 93.00 s

You can use the parameter Max. time of the curve to determine the initial value of the operate curve (for 20 · Threshold).
General information cannot be provided. Define the value corresponding to the application.

7.7.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Log.Inv.T KP #:Mode		• off • on • test	off
_:2	Log.Inv.T KP #:Operate & flt.rec. blocked		• no • yes	no
_:105	Log.Inv.T KP #:Directional mode		• forward • reverse	forward
_:8	Log.Inv.T KP #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:107	Log.Inv.T KP #:Directional comparison		• no • yes	no
_:106	Log.Inv.T KP #:Release via input signal		• no • yes	no
_:10	Log.Inv.T KP #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Log.Inv.T KP #:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:3	Log.Inv.T KP #: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
_:106	Log.Inv.T KP #:Time dial		0.05 to 1.50	0.20
_:101	Log.Inv.T KP #:Knee-point current	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
_:105	Log.Inv.T KP #:Knee-point time		0.00 s to 100.00 s	23.60 s
_:102	Log.Inv.T KP #:Current at Min. time	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	Log.Inv.T KP #:Min. time of the curve		0.00 s to 30.00 s	0.80 s
_:103	Log.Inv.T KP #:Max. time of the curve		0.00 s to 200.00 s	93.00 s

7.7.8.4 Information List

No.	Information	Data Class (Type)	Type
Stage #			
_:81	Log.Inv.T KP #:>Block stage	SPS	I
_:501	Log.Inv.T KP #:>Release delay & op.	SPS	I
_:500	Log.Inv.T KP #:>Block delay & op.	SPS	I
_:54	Log.Inv.T KP #:Inactive	SPS	O
_:52	Log.Inv.T KP #:Behavior	ENS	O
_:53	Log.Inv.T KP #:Health	ENS	O
_:60	Log.Inv.T KP #:Inrush blocks operate	SPS	O
_:55	Log.Inv.T KP #:Pickup	ACD	O
_:300	Log.Inv.T KP #:Direction	ACD	O
_:56	Log.Inv.T KP #:Operate delay expired	ACT	O
_:57	Log.Inv.T KP #:Operate	ACT	O

7.7.9 Stage with User-Defined Characteristic Curve

7.7.9.1 Description

Logic of the Stage

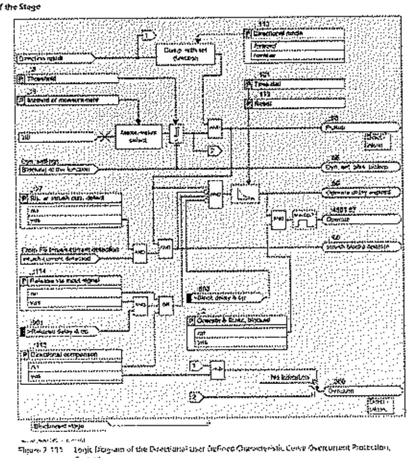


Figure 7-111 Logic Diagram of the Directional User-Defined Characteristic Curve Overcurrent Protection, Ground

This stage is structured in the same way as the inverse time-overcurrent protection – advanced stage (see chapter 7.7.6.1 Description). The only difference is that you can define the characteristic curve.
This section only discusses the nature of the operate curve. For further functionality, refer to chapter 7.7.6.1 Description.

User-Defined Characteristic Curve

With the directional, 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 User-Defined Characteristic Curves

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 threshold 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 outgoing. 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 started from 0.9 of the set threshold value.
The following figure shows the pickup behavior and dropout behavior when a directional user-defined characteristic curve is used.

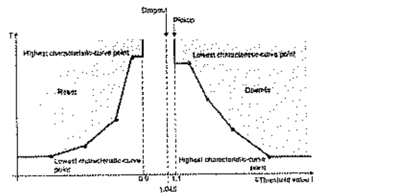


Figure 7-112 Pickup and Dropout Behavior when Using a User-Defined Characteristic Curve

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.

7.7.9.2 Application and Setting Notes

This stage is structured in the same way as the inverse time-overcurrent protection – advanced stage. The only difference is that you can define the characteristic curve as required. This section only provides application and setting notes for setting the characteristic curves. For guidance on the other parameters of the stage, see chapter 7.7.6.2 Application and Setting Notes.

Parameter: Current/time value pairs (of the Operate Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting follows 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 setting afterwards if you want to displace the characteristic curve.
Specify 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

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 system. Where no grading and therefore no displacement of the characteristic curve is required, leave the Time dial set to 1.

Parameter: Reset

- Default setting (_:110) Reset = disk emulation

The Reset parameter is used to define whether the stage drops out according to the dropout characteristic curve (behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Both operate curve and a dropout characteristic curve have to be specified with this setting. Use this setting if the device is coordinated with electromechanical devices or other devices performing dropout after disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation, that is, if instantaneous dropout is required.

Parameter: Current/time value pairs (of the Dropout Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic-curve point. The setting is determined by the characteristic curve you want to achieve.
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 setting afterwards if you want to displace the characteristic curve.
Specify 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.

7.7.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off

322

Addr.	Parameter	C	Setting Options	Default Setting
_2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_113	User curve #:Directional mode		• forward • reverse	forward
_8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_112	User curve #:Directional comparison		• no • yes	no
_114	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	1.200 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.set: AR off/n.ready				
_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

Addr.	Parameter	C	Setting Options	Default Setting
_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
_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.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	1.200 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.set: 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

Addr.	Parameter	C	Setting Options	Default Setting
_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

7.7.9.4 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	SPS	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
_300	User curve #:Direction	ACD	O
_56	User curve #:Operate delay expired	ACT	O
_57	User curve #:Operate	ACT	O

7.7.10 Influence of Other Functions via Dynamic Settings

7.5.8.1 Description and 7.5.8.2 Application and Setting Notes (Advanced Stage) describe the influence of other functions on dynamic settings.

7.8 Overcurrent Protection, 1-Phase

7.8.1 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

7.8.2 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 4 stages Definite time-overcurrent protection (UMZ)
- 1 stage Inverse time-overcurrent protection (AMZ)
- 1 stage User-defined characteristic curve overcurrent protection
- 1 Fast stage

In the function type 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 7-113 and Figure 7-114 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.

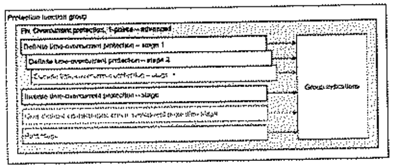


Figure 7-113 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Advanced

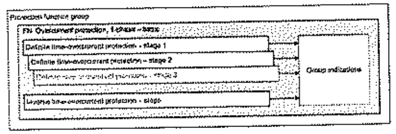


Figure 7-114 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Basic

If the device is equipped with the Inrush-current detection function, you can stabilize the stages against tripping of the operate indication due to transformer inrush currents.

7.8.3 Stage with Definite-Time Characteristic Curve

7.8.3.1 Description

Logic of a Stage

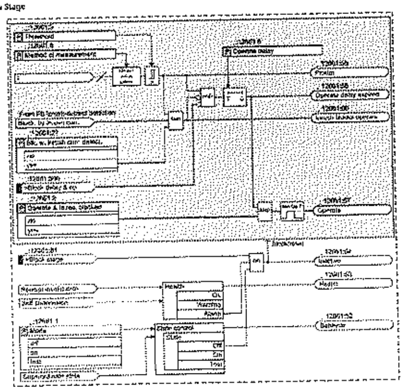


Figure 7-115 Logic Diagram of the Definite-Time Overcurrent Protection, 1-Phase

Method of measurement

You use the parameter Method of measurement 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

7.8.?.1 Description

7.8.3.2 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 $I_{rated,sec}$.

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.

7.8.3.3 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	0.10 s

7.8.3.4 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

7.8.4 Stage with Inverse-Time Characteristic Curve

7.8.4.1 Description

Logic of the Stage

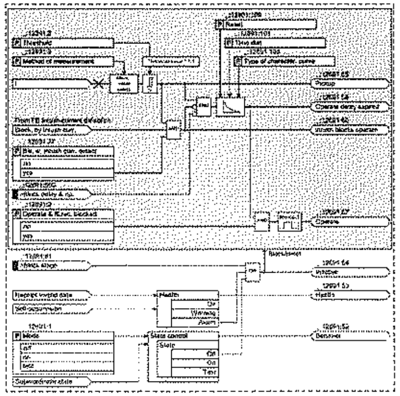


Figure 7-116 Logic Diagram of the Inverse-Time Overcurrent Protection (1-Phase)

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 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.

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.

7.8.4.2 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 $I_{rated,sec}$.

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 realized instead.

7.8.4.3 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 character. 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

7.8.4.4 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

7.8.5 Stage with User-Defined Characteristic Curve

7.8.5.1 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.

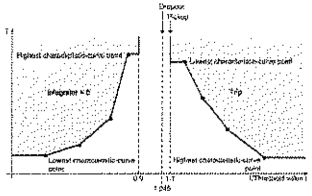


Figure 7-117 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

> **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.

7.8.5.2 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.

7.8.5.3 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
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00

7.8.5.4 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

No.	Information	Data Class (Type)	Type
_: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

7.9 Group Indications of Overcurrent Protection Functions

7.9.1 Description

The function block Group indications of the overcurrent protection functions uses the pickup and operate indications of the following functions:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Directional time overcurrent protection, phases
- Directional overcurrent protection, ground
- Ground-fault protection for high-resistance ground faults in grounded systems
- Instantaneous high-current tripping

The group indications of the overcurrent protection are generated by a logical OR of the stage-selective pickup and operate indications of the functions listed above (see also Figure 7-118):

- Pickup
- Operate

The pickup and operate indications are output, where present, with direction information.

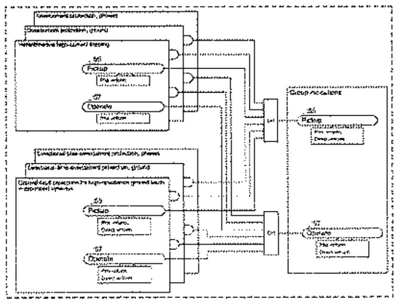


Figure 7-118 Logic Diagram of the Overcurrent Protection Group Indications

7.10 Inrush-Current Detection

7.10.1 Overview of Functions

The function Inrush-current detection

- Recognizes an inrush process on transformers
- Generates a blocking signal for protection functions that protect the transformer (protected object) or for protection functions that are affected in undesirable ways when transformers are switched on
- Allows a sensitive setting of the protection functions

The following protection functions evaluate the blocking signal:

- Overcurrent protection with a pickup value below the maximum inrush current
- Negative-sequence protection as sensitive backup protection for transformers

7.10.2 Structure of the Function

The function Inrush current detection is not an individual protection function. In the connection process of a transformer, it transmits a blocking signal to other protection functions. For this reason, the inrush-current detection must be in the same function group as the functions that are to be blocked.

The following figure shows the embedding of the function. The setting parameter Blk. w. inrush curr. detect. establishes the connection between Inrush-current detection and the functions that are to be blocked. If the parameter is set to yes, the connection is effective.

A jump detection or the threshold value exceeding of the functions to be blocked is used as trigger signal for synchronization of the internal measurement methods.

The jump detection reacts to changes in the current. The threshold value exceeding is recognized due to an internal pickup of the protection function that is to be blocked.

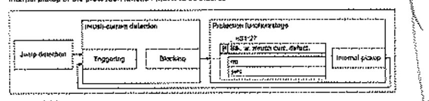


Figure 7-119 Structure/Embedding of the Function

7.10.3 Function Description

The function Inrush-current detection analyzes the trigger signal of the jump detection or the threshold value violation of the function to be blocked in a start logic, and synchronizes the method of measurement. In order to securely record the inrush processes, the function uses the Harmonic analysis method of measurement and the CWA method (current wave shape analysis). Both methods work in parallel and link the results through a logical OR.

If you wish to work with only one process, deactivate the other method by way of the parameters Blocking with 2. harmonic or Blocking with CWA.

325

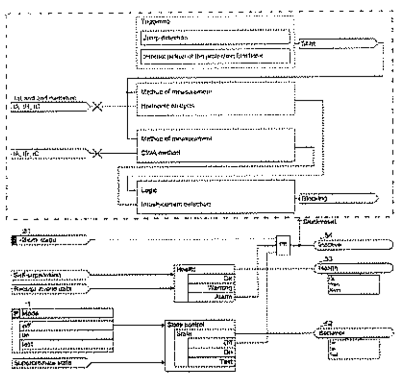


Figure 7-120 Basic Structure of the Inrush-Current Detection

Harmonic Analysis

For this method of measurement, the content of the 2nd harmonic and the fundamental component (1st harmonic) are determined for each of the phase currents I_A, I_B, and I_C and the quotient $I_{2nd\ harm.}$ / $I_{1st\ harm.}$ is formed from this. If this quotient exceeds the set threshold value, a phase-selective signal is issued. If 95 % of the set threshold value is exceeded, this leads to a pickup reset (dropout ratio = 0.95).

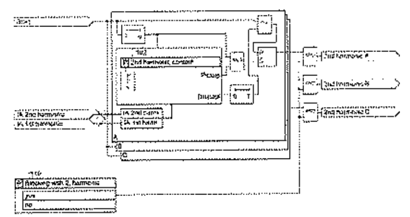


Figure 7-121 Logic of the Harmonic Analysis Function (T = 1 Period)

CWA Method (Current Wave Shape Analysis)

The CWA method executes a wave shape analysis of the phase currents IA, IB, and IC. If all 3 phase currents show flat areas at the same point in time, the inrush-current detection signal will be issued. The signal applies for all 3 phases simultaneously. The following figure shows a typical inrush-current characteristic, with the simultaneously occurring flat areas clearly recognizable.

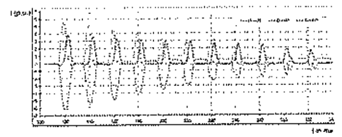


Figure 7-122 Inrush-Current Characteristic

The following figure shows the logic diagram of the CWA method.

From the present fundamental-component current (1st harmonic), the threshold value for identification of the flat areas is derived via an internal factor.

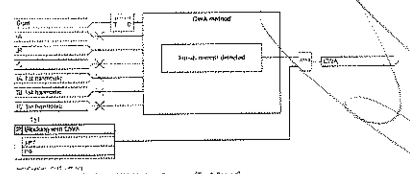


Figure 7-123 Logic of the CWA-Method Function (T = 1 Period)

Logic of the Inrush-Current Detection

The following logic diagram shows the link of the 2 methods of measurement Harmonic Analysis and CWA method.

The crossblock function influences the Harmonic Analysis process. If you have set the parameter Cross-blocking to yes, you will receive in the event of threshold value violation a blocking indication for all 3 phase currents and the measured or calculated zero-sequence current ($I_{gnd\ sens.}$ / $I_{gnd\ calc.}$). The crossblock function works via a timer. Set parameters for the time depending on the expected duration factor via the parameter Cross-blocking time.

If the phase current exceeds the maximum permissible current Operat.-range limit Imax, the inrush-current detection will be blocked.

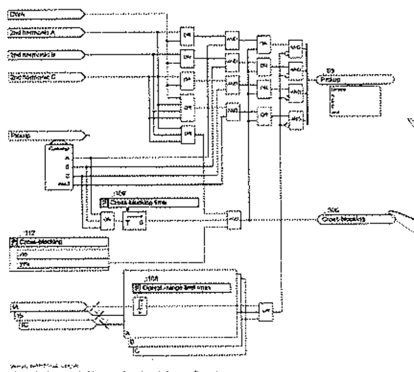


Figure 7-124 Logic Diagram of the Inrush-Current Detection

7.10.4 Application and Setting Notes

Parameter: Operat.-range limit Imax

- Recommended setting value (_:105) Operat.-range limit Imax = 7.5 A

With the parameter Operat.-range limit Imax, you can specify at which current the inrush-current detection is blocked internally. The setting value must be above the maximum inrush current of the transformer. A practicable value is 7.5 times the transformer rated current.

Parameter: Blocking with CWA

- Recommended setting value = (_:111) Blocking with CWA = yes

Parameter Value	Description
yes	CWA process activated.
no	CWA process deactivated.

Parameter: Blocking with 2. harmonic

- Recommended setting value (_:110) Blocking with 2. harmonic = yes

Parameter Value	Description
yes	Harmonic analysis process activated.
no	Harmonic analysis process deactivated.

NOTE

Make sure that at least one process is activated. Siemens recommends retaining the advised setting values.

Parameter: 2nd harmonic content

- Recommended setting value (_:102) 2nd harmonic content = 15 %

With the parameter 2nd harmonic content, you can specify the pickup value of the harmonic analysis function. The setting value of 15 % is practicable for most transformers.

Parameter: Cross-blocking

- Recommended setting value (_:112) Cross-blocking = no

Parameter Value	Description
no	Through the CWA process working in parallel in the inrush-current detection, the function is not activated as standard.
yes	If a subfunction of the inrush-current detection is identified in the course of the closure trials during commissioning, set the parameter Cross-blocking to yes.

Parameter: Cross-blocking time

- Default setting (_:109) Cross-blocking time = 0.06 s

You define the duration of this blocking with the Cross-blocking time parameter. The default setting of 0.06 s (about 3 periods) has proven practicable. Set the time as short as possible and check the value during the closure trials. The parameter Cross-blocking time is inactive at Cross-blocking = no.

Parameter: Start flt.rec

- Default setting (_:114) Start flt.rec = yes

With the Start flt.rec parameter, you determine whether a fault record should be started upon pickup of the inrush-current detection. The following settings are possible:

Parameter Value	Description
no	No fault recording starts with pickup.
yes	The fault recording starts with pickup. When the protection function is blocked by the inrush-current detection, a fault recording is started nevertheless.

7.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inrush detect.				
_:1	Inrush detect.:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:105	Inrush detect.:Operat.-range limit Imax	1 A @ 100 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	7.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	37.500 A
_:111	Inrush detect.:Blocking with CWA		• no • yes	yes
_:110	Inrush detect.:Blocking with 2. harmonic		• no • yes	yes
_:102	Inrush detect.:2nd harmonic content		10 % to 45 %	15 %
_:112	Inrush detect.:Cross-blocking		• no • yes	no
_:109	Inrush detect.:Cross-blocking time		0.03 s to 200.00 s	0.06 s
_:114	Inrush detect.:Start flt.rec		• no • yes	yes

7.10.6 Information List

No.	Information	Data Class (Type)	Type
Inrush detect.			
_:81	Inrush detect.:>Block stage	SPS	I
_:54	Inrush detect.:Inactive	SPS	O
_:52	Inrush detect.:Behavior	ENS	O
_:53	Inrush detect.:Health	ENS	O
_:300	Inrush detect.:2.harmonic phase A	SPS	O
_:301	Inrush detect.:2.harmonic phase B	SPS	O
_:302	Inrush detect.:2.harmonic phase C	SPS	O
_:305	Inrush detect.:CWA	SPS	O
_:306	Inrush detect.:Cross-blocking	SPS	O
_:55	Inrush detect.:Pickup	ACD	O

326

7.11 Instantaneous High-Current Tripping

7.11.1 Overview of Functions

The Instantaneous high-current tripping function has the following tasks:

- Instantaneous tripping when switching onto an existing fault, for example, if a grounding switch is closed
- Instantaneous disconnection of high currents above the highest overcurrent-protection stage.

7.11.2 Structure of the Function

The Instantaneous high-current tripping function offers 2 different increment types:

- Stage with standard release method
- Stage with release method via protection interface (only applicable if the device is equipped with a protection interface)

The function with the stage for the standard release procedure is factory-set.

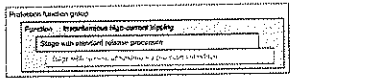


Figure 7-125 Structure/Embedding of the Function

7.11.3 Standard Release Procedure

Logic

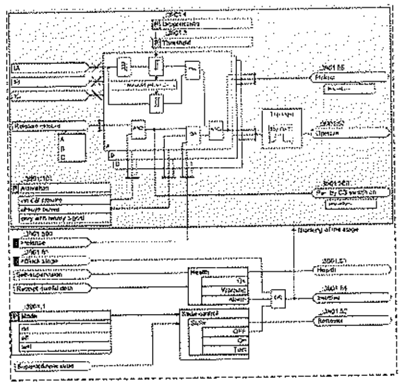


Figure 7-126 Logic Diagram of Instantaneous High-Current Tripping with Standard Release Method

Activation

Using the Activation parameter, you set the conditions under which the stage is released.

- on CB closure

With this procedure, the stage is released only if the circuit breaker is about to be closed (the CB is open) or if the circuit breaker is being closed or if the binary input signal >release is active. The only signals are generated: rel. by CB switch on as described in section 5.5.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions.

- always active

The stage is always released and is thus independent of closing of the circuit breaker switch and of the binary input signal >release.

- only with binary signal

The stage is released only if the binary input signal >release is active.

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds a preset threshold value by
  current > 2·√2·threshold value
  this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

7.11.4 Application and Setting Notes

Parameter: Activation

- Default setting (_:3901:101) Activation = on CB closure

Using the parameter Activation, you define the conditions under which the stage is released.

Parameter Value	Description
on CB closure	Select this setting to activate the stage only when the circuit breaker is closed.
always active	Select this setting to release the stage statically.
only with binary signal	Select this setting to release the stage via an external signal.

Parameter: Threshold

- Default setting (_:3901:3) Threshold = 10.0 A for I_{rated} = 1 A or 50.0 A for I_{rated} = 5 A

The stage works independently of the position of the remote circuit breakers. For this reason, set the Threshold so that the fault current flowing through does not trigger the stage. Thus, use this stage only if current grading over the protected object is possible, that is, for transformers, shunt reactors or long lines with low source impedance. In other cases, deactivate the stage.

EXAMPLE

Calculation example for current grading of a 110 kV overhead line measuring 150 mm²

s (length) = 100 km

R_1/s = 0.21 Ω/km

X_1/s = 0.43 Ω/km

Since the stage is non-directional, the calculation must consider the maximum short-circuit power at the start of the line or at the opposite end:

S_{sc}'' = 3.5 GVA (subtransient, because the function can respond to the 1st peak value)

Current transformer 600 A/5 A

The line impedance Z_L and the minimum source impedance Z_S are calculated on this basis:

Line impedance Z_L and Source impedance Z_S: $Z_L/s = \sqrt{0.21^2 + 0.43^2}$ Ω/km = 0.479 Ω/km

Z_L = 0.479 Ω/km · 100 km = 47.9 Ω

$$Z_S = \frac{110\,kV^2}{3500\,MVA} = 3.46\ Ω$$

The maximum 3-phase short-circuit current I_{sc} flowing through is (at a source voltage of 1.1 V_N):

$$I_{sc} = \frac{1.1 \cdot V_{Nom}}{\sqrt{3} \cdot (Z_S + Z_L)} = \frac{1.1 \cdot 110\,kV}{\sqrt{3} \cdot (3.46\,Ω + 47.9\,Ω)} = 1360\ A$$

With a safety margin of 10 %, the following setting value results:

- **Threshold value (primary)** = 1.1 · 1360 A = 1496 A
- **Threshold value (secondary)** = $1.1 \cdot \frac{1360\,A}{600\,A} \cdot 5\,A$ = 12.5 A

If short-circuit currents exceed 1496 A (primary) or 12.5 A (secondary), there is a short circuit on the line to be protected. It can be disconnected immediately.

NOTE

The calculation was performed with absolute values, which is accurate enough for overhead lines. A complex calculation is required only if the source impedance and the line impedance have extremely different angles.

Parameter: Dropout ratio

- Recommended setting value (_:3901:4) 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 setting value of the parameter Dropout ratio. This avoids chattering of the tripping stage.

7.11.5 Release Procedure via Protection Interface

This stage can be applied only if the device is equipped with a protection interface.

Logic

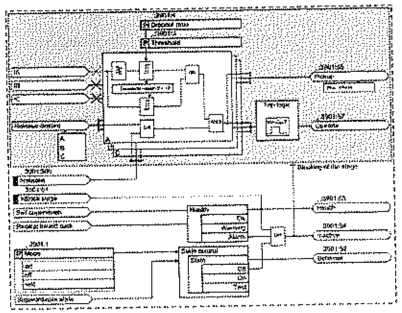


Figure 7-127 Logic Diagram of Instantaneous High-Current Tripping with Release Procedure via Protection Interface

Release

If one of the following conditions is fulfilled, the stage is released (the internal Release signal is present) (for further information, see chapter 5.7.3 Overview of Functions):

- No voltage has yet been applied to the protected object, which means that the remote circuit breakers are open, or
- Switching to the local circuit breaker is imminent.

These conditions are recognized internally if a circuit breaker is open or just closing.

Furthermore, the stage can be activated externally via the >release binary input signal.

NOTE

To enable internal release of the stage, the devices at all ends of the protected object must be informed of the circuit-breaker position (the circuit-breaker auxiliary contacts must be connected to the devices; the respective binary input signals must be configured).

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds a preset threshold value by
  current ≥ 2·√2·threshold value
  this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

7.11.6 Application and Setting Notes

Parameter: Threshold

- Default setting (_:3901:3) Threshold = 2.5 A for I_{rated} = 1 A or 12.5 A for I_{rated} = 5 A

Select the value high enough for the protection not to pick up on the RMS value of the inrush current that occurs when the local circuit breaker is closed. You do not have to consider short-circuit currents flowing through, because the stage is released only if the circuit breakers are opened at all remote ends of the protected object or the release was caused by the binary input >release.

Parameter: Dropout ratio

- Recommended setting value (_:3901:4) Dropout ratio = 0.90

The recommended setting value of 0.90 is sufficient for many applications. To obtain extremely accurate measurements, the dropout ratio can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the dropout ratio. This avoids chattering of the tripping stage.

7.11.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Standard 1				
_:3901:1	Standard 1:Mode		• off • on • test	on
_:3901:101	Standard 1:Activation		• on CB closure • only with binary signal • always active	on CB closure
_:3901:3	Standard 1: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
_:3901:4	Standard 1:Dropout ratio		0.50 to 0.90	0.90

7.11.8 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O

324

No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
Standard 1			
_:3901:500	Standard 1:>Release	SPS	I
_:3901:81	Standard 1:>Block stage	SPS	I
_:3901:54	Standard 1:Inactive	SPS	O
_:3901:52	Standard 1:Behavior	ENS	O
_:3901:53	Standard 1:Health	ENS	O
_:3901:300	Standard 1:Rel. by CB switch-on	ACT	O
_:3901:55	Standard 1:Pickup	ACD	O
_:3901:57	Standard 1:Operate	ACT	O

7.12 Voltage-Dependent Overcurrent Protection

7.12.1 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

7.12.2 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

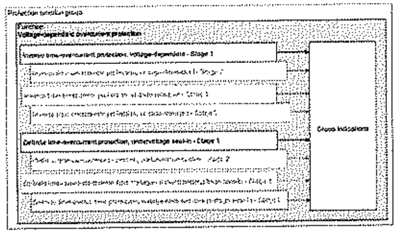


Figure 7-128 Structure/Embedding of the Function

7.12.3 Stage Description Overcurrent Protection, Voltage-Dependent

7.12.3.1 Description

Logic of the Stage

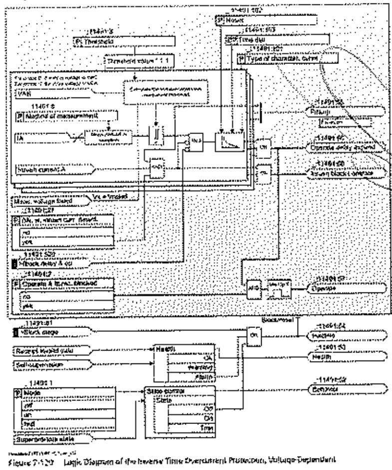


Figure 7-129 Logic Diagram of the Inverse Time Overcurrent Protection, Voltage-Dependent

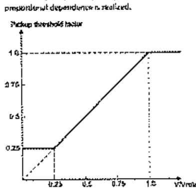
Method of Measurement

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 7-130). In the range between V/V_{rated} = 1.00 to 0.25 a linear, directly proportional dependence is realized.



PU(V) = PU-sett. * 1.00   for 1.00 ≤ V/Vrated ≤ ∞

PU(V) = PU-sett. * V/Vrated   for 0.25 ≤ V/Vrated ≤ 1.00

PU(V) = PU-sett. * 0.25   for 0.00 ≤ V/Vrated ≤ 0.25

Figure 7-130 Voltage Influence of the Pickup Threshold

With:

V	=	Measured phase-to-phase voltage
V_{rated}	=	Rated voltage (parameter Rated voltage in the function block General of the protection function group)
PU sett.	=	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 7-8.

Table 7-8 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 7.4.7.1 Description.

7.12.3.2 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 method.
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 disc) 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).

7.12.4 Stage Description Voltage-Independent Overcurrent Protection

7.12.4.1 Description

Logic of the Stage

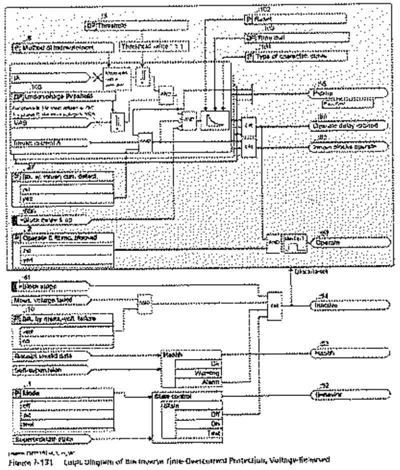


Figure 7-131 Logic Diagram of the Inverse Time-Overcurrent Protection, Voltage-Released

This stage is structured in the same way as the inverse time-overcurrent, voltage-dependent stage (see chapter 7.12.3.1 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 measuring phases is shown in Figure 7-131.

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 VT miniature 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.

7.12.4.2 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 7.12.3.2 Application and Setting Notes.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:110) 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}.

7.13 Overvoltage Protection with 3-Phase Voltage

7.13.1 Overview of Functions

The function Overvoltage protection with 3-phase voltage (ANSI 59) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components, machines, etc.) against damages caused by overvoltage
- Decouple systems (for example, wind power supply)

Abnormally high voltages in power systems are caused by voltage controller failure at the transformer or on long transmission lines under low-load conditions.

When using compensation reactors in the protected power system, the device must shut down the line quickly if the reactors fail (for example, due to fault clearance). The insulation is endangered by the overvoltage condition.

Overvoltages at capacitor banks can be caused by resonances with line or transformer inductances.

In power plants increased voltage levels can be due to one of these factors:

- Incorrect operation when controlling the excitation system manually
- Failure of the automatic voltage controller
- After full load shedding of a generator
- Generators which are disconnected from the network or in island mode

7.13.2 Structure of the Function

The Overvoltage protection with 3-phase voltage function is used in protection function groups with voltage measurement.

The Overvoltage protection with 3-phase voltage function is preconfigured by the manufacturer with 2 Definite time-overvoltage protection stages. In this function, the following stages can operate simultaneously:

- 3 stages Definite time-overvoltage protection
- 2 stages Inverse time-overvoltage protection

Stages that are not preconfigured are shown in gray in the following figure.

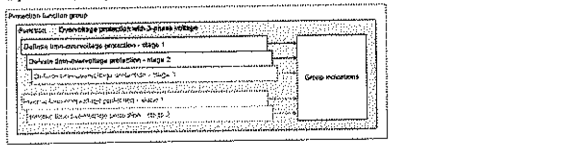


Figure 7-132 Structure/Embedding of the Function

7.13.3 Description

Logic of the Stage

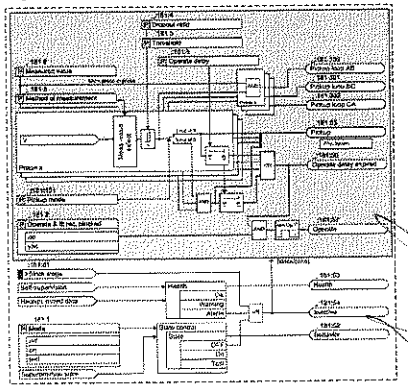


Figure 7-133 Logic Diagram of the Definite Time-Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the RMS value.

- Measurement: Fundamental comp.:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement: RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

The Pickup mode parameter defines whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (3 out of 3) or if only 1 measuring element detects the overvoltage condition (1 out of 3).

Measured Value

Use the Measured value parameter to define whether the tripping stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible internally or externally via the binary input signal >Block stage.

7.13.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:181:8) Method of measurement = fundamental comp.

With the Method of measurement parameter, you define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the threshold value of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting (_:181:9) Measured value = phase-to-phase

With the Measured value parameter, you define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep phase-to-phase as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value phase-to-phase as the default setting.
phase-to-ground	Select the phase-to-ground setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting (_:181:3) Threshold = 110 V

Depending on the Measured value, the Threshold is set either as phase-to-phase quantity or as phase-to-ground quantity. The default setting assumes that the voltage range is monitored on long-distance transmission lines under low-load conditions.

Specify the Threshold (pickup threshold) for the specific application.

Parameter: Operate delay

- Default setting (_:181:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:181:4) Dropout ratio = 0.95

The recommended set 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: Pickup mode

- Recommended setting value (_:181:101) Pickup mode = 1 out of 3

With the Pickup mode parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (3 out of 3) or if only 1 measuring element detects the overvoltage condition (1 out of 3).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends 1 out of 3 as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

EXAMPLE

Example for 2-stage overvoltage protection

The example describes the possible settings for a 2-stage overvoltage protection function. We will look at the settings of the parameters Threshold and Operate delay.

- 1. Stage:
  To detect stationary overvoltages, set the threshold value of the first overvoltage-protection element at least 10 % above the max. stationary phase-to-phase voltage anticipated during normal operation. When setting the parameter Measured value, to phase-to-phase voltage and a secondary rated voltage of 100 V, the secondary setting value of the first overvoltage-protection element is calculated as follows:

Threshold value: 10 % above V_{rated}

$V_{rated,sec} = 1.1\ V_{rated,sec} = 1.1 \cdot 100\ V = 110\ V$

This requires that the primary rated voltages of protected object and voltage transformer are identical. If they are different, you have to adjust the pickup value.

For the Operate delay set a value of 3 s.

- 2. Stage:
  The second overvoltage-protection stage is intended for high overvoltages with short duration. A high pickup value is selected here, for example, 1.5 times the rated voltage. A time-delay setting of 0.1 s to 0.2 s is sufficient then.

Stage	Setting Values	
	Threshold value	Time delay
1	[illegible] 1.1 V_{rated}	3 s

329

Stage	Setting Values	
2	1.5 V_{thresh}	0.1 s to 0.2 s

7.13.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:181:1	Definite-T 1:Mode		• off • on • test	off
_:181:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:181:9	Definite-T 1:Measured value		• phase to ground • phase to phase	phase to phase
_:181:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:181:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:181:3	Definite-T 1:Threshold		0.300 V to 340.000 V	110.000 V
_:181:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:181:6	Definite-T 1:Operate delay		0.00 s to 300.00 s	3.00 s
Definite-T 2				
_:182:1	Definite-T 2:Mode		• off • on • test	off
_:182:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:182:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:182:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:182:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:182:3	Definite-T 2:Threshold		0.300 V to 340.000 V	130.000 V
_:182:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:182:6	Definite-T 2:Operate delay		0.00 s to 300.00 s	0.50 s

7.13.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:181:81	Definite-T 1:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_:181:54	Definite-T 1:Inactive	SPS	O
_:181:52	Definite-T 1:Behavior	ENS	O
_:181:53	Definite-T 1:Health	ENS	O
_:181:55	Definite-T 1:Pickup	ACD	O
_:181:300	Definite-T 1:Pickup loop AB	SPS	O
_:181:301	Definite-T 1:Pickup loop BC	SPS	O
_:181:302	Definite-T 1:Pickup loop CA	SPS	O
_:181:56	Definite-T 1:Operate delay expired	ACT	O
_:181:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:182:81	Definite-T 2:>Block stage	SPS	I
_:182:54	Definite-T 2:Inactive	SPS	O
_:182:52	Definite-T 2:Behavior	ENS	O
_:182:53	Definite-T 2:Health	ENS	O
_:182:55	Definite-T 2:Pickup	ACD	O
_:182:300	Definite-T 2:Pickup loop AB	SPS	O
_:182:301	Definite-T 2:Pickup loop BC	SPS	O
_:182:302	Definite-T 2:Pickup loop CA	SPS	O
_:182:56	Definite-T 2:Operate delay expired	ACT	O
_:182:57	Definite-T 2:Operate	ACT	O

7.13.7 Description

Logic of the Stage

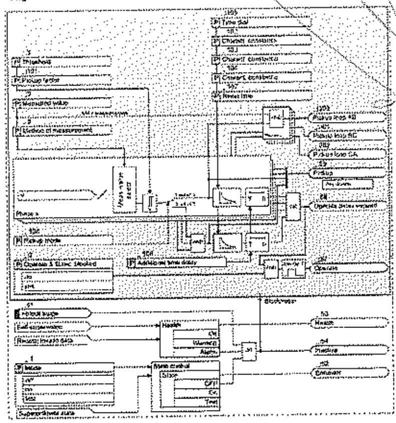


Figure 7-134 Logic Diagram of the Inverse-Time Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the RMS value.

- Measurement fundamental comp.:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

With the Pickup mode parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (3 out of 3) or if only 1 measuring element detects the overvoltage condition (1 out of 3).

Measured Value

Use the Measured value parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC} and V_{CA} or the phase-to-ground voltages V_A, V_B and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup and Operate Curve

When the input voltage exceeds the threshold value by a settable value Pickup factor, the stage picks up and the inverse-time characteristic curve is processed. Operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

$T_{op} = T_{inv} + T_{add}$

Where

T_{op} Operate delay

T_{inv} Inverse-time delay

T_{add} Additional time delay (parameter Additional time delay)

After pickup, the time value T_{inv} is calculated for every input voltage that exceeds the threshold. An integrator accumulates the value $1/T_{inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The additional time delay T_{add} starts. The stage operates after the additional time delay expires.

The inverse-time characteristic is shown in the following figure.

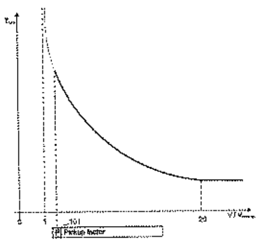


Figure 7-135 Operate Curve of Inverse-Time Characteristic

The inverse-time delay is calculated with the following formula:

$$T_{inv} = T_p\left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c\right) [s]$$

Where

T_{inv} Inverse-time delay

T_p Time multiplier (parameter Time dial)

V Measured voltage

V_{thresh} Threshold value (parameter Threshold)

k Curve constant k (parameter Charact. constant k)

α Curve constant α (parameter Charact. constant α)

c Curve constant c (parameter Charact. constant c)

When V/V_{thresh} is equal to or greater than 20, the inverse-time delay does not decrease any further.

Dropout Behavior

When the voltage falls below the dropout threshold (0.95 · pickup factor · threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter Reset time. Instantaneous reset takes place by setting Reset time to 0 s. A delayed reset takes place by setting the desired delay time.

During the Reset time (> 0 s), the elapsed operate delay is frozen. If the pickup value is exceeded again within this period, the stage operates when the rest of operate delay expires.

Blocking the Stage

In the event of blocking, the picked-up stage will be reset. Blocking is possible externally or internally via the binary input signal >Block stage.

7.13.8 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:8) Method of measurement = fundamental comp.

With the Method of measurement parameter, you define whether the tripping stage uses the fundamental component (standard method - default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the threshold value of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting (_:9) Measured value = phase-to-phase

With the Measured value parameter, you define whether the tripping stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep phase-to-phase as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value phase-to-phase as the default setting.
phase-to-ground	Select the phase-to-ground setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold, Pickup factor

- Default setting (_:3) Threshold = 110.000 V
- Default setting (_:102) Pickup factor = 1.10

The stage picks up when the measured voltage value exceeds the pickup value Threshold * Pickup factor.

Depending on the Measured value, the Threshold is set either as phase-to-phase quantity or as phase-to-ground quantity.

With the Pickup factor parameter, you modify the pickup value. To avoid a long-time operate delay after pickup when the measured value is slightly over the threshold, Siemens recommends using the default setting.

Specify the Threshold (pickup threshold) and Pickup factor for the specific application.

Parameter: Pickup mode

- Recommended setting value (_:182:101) Pickup mode = 1 out of 3

With the Pickup mode parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (3 out of 3) or if only 1 measuring element detects the overvoltage condition (1 out of 3).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends 1 out of 3 as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using this stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting (_:103) Charact. constant k = 1.00
- Default setting (_:104) Charact. constant α = 1.000
- Default setting (_:105) Charact. constant c = 0.000

With the parameters Charact. constant k, Charact. constant α, and Charact. constant c, you define the required inverse-time characteristic curve.

Parameter: Time dial

- Default setting (_:106) Time dial = 1.00

With the Time dial parameter, you displace the characteristic curve in the time direction. As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve. Siemens recommends leaving the Time dial parameter at 1.00 (default setting).

Parameter: Additional time delay

- Default setting (_:107) Additional time delay = 0.00 s

330

With the Additional time delay parameter, 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, only the inverse time delay is operative.

Parameter: Reset time

- Default setting (_:107) Reset time = 0.00 s

With the Reset time parameter, you define the reset time delay which is started when the voltage falls below the dropout threshold. Set the parameter Reset time to 0 s when instantaneous reset is desired. Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the Reset time to an appropriate value (> 0 s) to ensure the operation. Otherwise Siemens recommends to keep the default value to ensure a fast reset of the function.

7.13.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:108	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:3	Inverse-T #:Threshold		0.300 V to 340.000 V	110.000 V
_:101	Inverse-T #:Pickup factor		1.00 to 1.20	1.10
_:102	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:103	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:104	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:105	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:106	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:107	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

7.13.10 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

7.14 Overvoltage Protection with Positive-Sequence Voltage

7.14.1 Overview of Functions

The function Overvoltage protection with positive-sequence voltage (ANSI 59) is used for:

- Detect symmetric stationary overvoltages
- Supervise the voltage range if the positive-sequence voltage is the decisive quantity

Unbalanced overvoltages, for example, caused by ground faults and single-ended faults, are not detected due to the evaluation of the positive-sequence voltage.

7.14.2 Structure of the Function

The Overvoltage protection with positive-sequence voltage function is used in protection function groups, which are based on voltage measurements.
The function Overvoltage protection with positive-sequence voltage comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

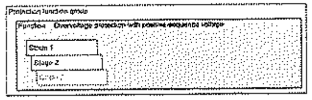


Figure 7-136 Structure/Embedding of the Function

7.14.3 Stage Description

Logic of a Stage

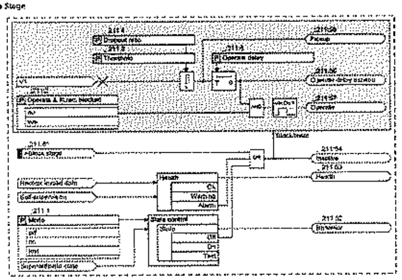


Figure 7-137 Logic Diagram of a Stage: Overvoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal >Block stage.

7.14.4 Application and Setting Notes

Parameter: Threshold

- Default setting (_:211:3) Threshold = 65 V

The Threshold is set according to the definition of the positive-sequence system.
Specify the Threshold (pickup threshold) for the specific application.

Parameter: Operate delay

- Default (_:211:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:211:4) Dropout ratio = 0.95

The default 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.

General Notes

If the overvoltage is high, the first stage can trip with a short time delay. If overvoltages are lower, the second stage can either only signal the threshold value violation (see Operation as monitoring function) or trip with a longer delay to allow the voltage controller to regulate the voltage back into the nominal range.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

7.14.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:211:1	Stage 1:Mode		• off • on • test	off
_:211:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:211:3	Stage 1:Threshold		0.300 V to 200.000 V	65.000 V
_:211:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:211:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:212:1	Stage 2:Mode		• off • on • test	off
_:212:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:212:3	Stage 2:Threshold		0.300 V to 200.000 V	75.000 V
_:212:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:212:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

7.14.6 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			
_:211:81	Stage 1:>Block stage	SPS	I
_:211:54	Stage 1:Inactive	SPS	O
_:211:52	Stage 1:Behavior	ENS	O
_:211:53	Stage 1:Health	ENS	O
_:211:55	Stage 1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:211:56	Stage 1:Operate delay expired	ACT	O
_:211:57	Stage 1:Operate	ACT	O
Stage 2			
_:212:81	Stage 2:>Block stage	SPS	I
_:212:54	Stage 2:Inactive	SPS	O
_:212:52	Stage 2:Behavior	ENS	O
_:212:53	Stage 2:Health	ENS	O
_:212:55	Stage 2:Pickup	ACD	O
_:212:56	Stage 2:Operate delay expired	ACT	O
_:212:57	Stage 2:Operate	ACT	O

32

7.15 Overvoltage Protection with Any Voltage

7.15.1 Overview of Functions

The function Overvoltage protection with any voltage (ANSI 59) detects any 1-phase overvoltages and is intended for special applications.

7.15.2 Structure of the Function

The Overvoltage protection with any voltage function is used in protection function groups, which are based on voltage measurement.

The function Overvoltage protection with any voltage comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

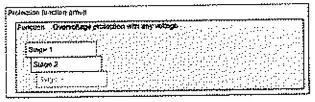


Figure 7-138 Structure/Embedding of the Function

7.15.3 Stage Description

Logic of a Stage

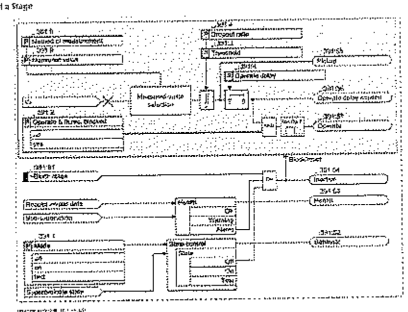


Figure 7-139 Logic Diagram of a Stage: Overvoltage Protection with Any Voltage

> **NOTE**
> If the function Overvoltage protection with any voltage is used in a 1-phase function group, the parameter Measured value is not visible.

Method of Measurement

The Method of measurement parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the fundamental comp.:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the parameter value RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter Measured value allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function Overvoltage protection with any voltage is used in a 1-phase function group, the parameter Measured value is not visible.

Blocking the Stage

In the event of blocking, the picked-up stage will be reset. Blocking is possible externally or internally via the binary input signal >Block stage.

7.15.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:391:8) Method of measurement = fundamental comp.

Use the Method of measurement parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the threshold value of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting (_:391:9) Measured value = VA measured

The Measured value parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the Appendix.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (VA measured)
- Measured phase-to-ground voltage V_B (VB measured)
- Measured phase-to-ground voltage V_C (VC measured)
- Measured phase-to-phase voltage V_{AB} (VAB measured)
- Measured phase-to-phase voltage V_{BC} (VBC measured)
- Measured phase-to-phase voltage V_{CA} (VCA measured)
- Measured voltage VN (VN measured)
- Measured phase-to-phase voltage V_{AB} (VAB calculated)
- Measured phase-to-phase voltage V_{BC} (VBC calculated)
- Measured phase-to-phase voltage V_{CA} (VCA calculated)
- Calculated voltage V0 (V0 calculated)

The selection depends on the corresponding application.

> **NOTE**
> If the function Overvoltage protection with any voltage is used in a 1-phase function group, the parameter Measured value is not visible.

Parameter: Threshold

- Default setting (_:391:3) Threshold = 110 V

Specify the Threshold (pickup threshold) for the specific application.

Depending on the measured value, the Threshold is set either as Measured voltage or as Phase-to-phase quantity.

Parameter: Operate delay

- Default setting (_:391:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:391:4) Dropout ratio = 0.95

The recommended set 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.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

7.15.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:391:1	Stage 1:Mode		• off • on • test	off
_:391:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:391:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VN measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:391:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:391:3	Stage 1:Threshold		0.300 V to 340.000 V	110.000 V
_:391:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:391:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:392:1	Stage 2:Mode		• off • on • test	off
_:392:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:392:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VN measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:392:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:392:3	Stage 2:Threshold		0.300 V to 340.000 V	130.000 V
_:392:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:392:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

7.15.6 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			
_:391:81	Stage 1:>Block stage	SPS	I
_:391:54	Stage 1:Inactive	SPS	O
_:391:52	Stage 1:Behavior	ENS	O
_:391:53	Stage 1:Health	ENS	O
_:391:55	Stage 1:Pickup	ACD	O
_:391:56	Stage 1:Operate delay expired	ACT	O
_:391:57	Stage 1:Operate	ACT	O
Stage 2			
_:392:81	Stage 2:>Block stage	SPS	I
_:392:54	Stage 2:Inactive	SPS	O
_:392:52	Stage 2:Behavior	ENS	O
_:392:53	Stage 2:Health	ENS	O
_:392:55	Stage 2:Pickup	ACD	O
_:392:56	Stage 2:Operate delay expired	ACT	O
_:392:57	Stage 2:Operate	ACT	O

7.16 Undervoltage Protection with 3-Phase Voltage

7.16.1 Overview of Functions

The function Undervoltage protection with 3-phase voltage (ANSI 27) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components and machines) against damages caused by undervoltage
- Handle disconnection or load shedding tasks in a system

7.16.2 Structure of the Function

The Undervoltage protection with 3-phase voltage function is used in protection function groups with voltage measurement.

The Undervoltage protection with 3-phase voltage function is preconfigured by the manufacturer with 2 Definite time-undervoltage protection stages.

In the function Undervoltage protection with 3-phase voltage, the following stages can be operated simultaneously:

- 3 stages Definite time-undervoltage protection
- 2 stages Inverse time-undervoltage protection

Stages that are not preconfigured are shown in gray in the following figure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see Figure 7-140). If the protection function group used has no current measurement, you can only set the current-flow criterion as fulfilled via the corresponding binary input signal.

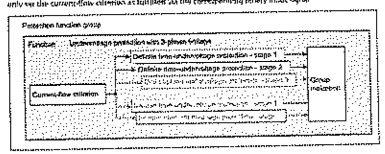


Figure 7-140 Structure/Embedding of the Function

7.16.3 Description

Logic of a Stage

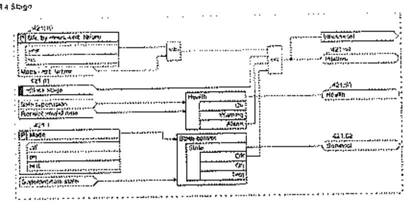


Figure 7-141 Logic Diagram of the Stage Control

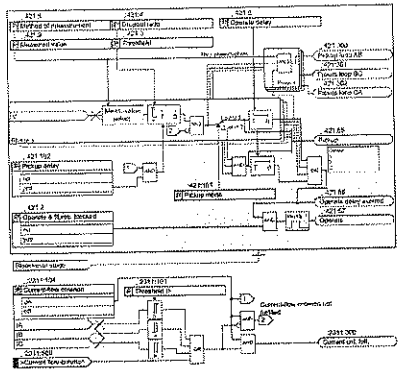


Figure 7-142 Logic Diagram of the Function

Method of Measurement

With the Method of measurement parameter, you select the relevant method of measurement, depending on the application.

- Measurement fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

With the Measured value parameter, you define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Mode

With the Pickup mode setting, you define whether the stage picks up when there is a lower threshold-value violation in one measuring element (1 out of 3) or when there is a lower threshold-value violation in all 3 measuring elements (3 out of 3).

Pickup Delay

The Pickup delay parameter is only relevant at the end of a fault if you are using the current-flow criterion of the function (parameter Current-flow criterion = on).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow criterion functions conflict with one another. Depending on the threshold-value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the Pickup delay parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The Current-flow criterion works across all tripping stages.

When the Current-flow criterion parameter is activated, the undervoltage-protection stages only pick up if a settable minimum current (Threshold I>) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to fulfilled with the binary input signal >Current flow-criterion. The function reports when the current-flow criterion is fulfilled.

Figure 7-142 illustrates the influence of the current-flow criterion.

NOTE

If the (_:2311:104) Current-flow criterion parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

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. 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 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.

7.16.4 Application and Setting Notes

Parameter: Pickup mode

- Recommended setting value (_:421:101) Pickup mode = 1 out of 3

With the Pickup mode parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (1 out of 3) or when there is a lower threshold-value violation in all 3 measuring elements (3 out of 3).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends 1 out of 3 as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting (_:421:102) Pickup delay = no

The Pickup delay parameter is only available if you are using the current-flow criterion of the function (parameter Current-flow criterion = on). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter Pickup delay you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for undervoltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

7.16.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 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
Definite-T 1				
_:421:1	Definite-T 1:Mode		• off • on • test	off
_:421:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:421:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:421:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase

Addr.	Parameter	C	Setting Options	Default Setting
_:421:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:421:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:421:102	Definite-T 1:Pickup delay		• no • yes	no
_:421:3	Definite-T 1:Threshold		0.300 V to 175.000 V	80.000 V
_:421:4	Definite-T 1:Dropout ratio		1.01 to 1.20	1.05
_:421:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	3.00 s
Definite-T 2				
_:422:1	Definite-T 2:Mode		• off • on • test	off
_:422:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:422:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:422:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:422:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:422:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:422:102	Definite-T 2:Pickup delay		• no • yes	no
_:422:3	Definite-T 2:Threshold		0.300 V to 175.000 V	65.000 V
_:422:4	Definite-T 2:Dropout ratio		1.01 to 1.20	1.05
_:422:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

7.16.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:421:81	Definite-T 1:>Block stage	SPS	I
_:421:54	Definite-T 1:Inactive	SPS	O
_:421:52	Definite-T 1:Behavior	ENS	O
_:421:53	Definite-T 1:Health	ENS	O
_:421:55	Definite-T 1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:421:300	Definite-T 1:Pickup loop AB	SPS	O
_:421:301	Definite-T 1:Pickup loop BC	SPS	O
_:421:302	Definite-T 1:Pickup loop CA	SPS	O
_:421:56	Definite-T 1:Operate delay expired	ACT	O
_:421:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:422:81	Definite-T 2:>Block stage	SPS	I
_:422:54	Definite-T 2:Inactive	SPS	O
_:422:52	Definite-T 2:Behavior	ENS	O
_:422:53	Definite-T 2:Health	ENS	O
_:422:55	Definite-T 2:Pickup	ACD	O
_:422:300	Definite-T 2:Pickup loop AB	SPS	O
_:422:301	Definite-T 2:Pickup loop BC	SPS	O
_:422:302	Definite-T 2:Pickup loop CA	SPS	O
_:422:56	Definite-T 2:Operate delay expired	ACT	O
_:422:57	Definite-T 2:Operate	ACT	O

7.16.7 Description

Logic

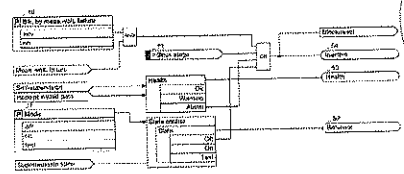


Figure 7-143 Logic Diagram of the Stage Control

333

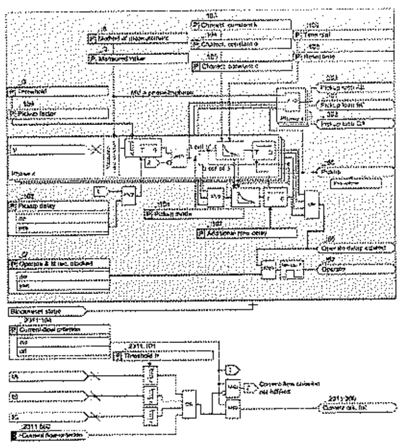


Figure 7-144 Logic Diagram of the Function

Method of Measurement

Use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the RMS value.

- Measurement fundamental comp.:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

Use the Measured value parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Mode

Use the Pickup mode parameter to define whether the stage picks up when there is a lower threshold-value violation in one measuring element (1 out of 3) or when there is a lower threshold-value violation in all 3 measuring elements (3 out of 3).

Pickup and Operate Curve

When the input voltage falls below the threshold value by a settable value Pickup factor, the stage picks up and the inverse-time characteristic curve is processed. The operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay:

$T_{op} = T_{inv} + T_{add}$

Where:

T_{op}	Operate delay
T_{inv}	Inverse-time delay
T_{add}	Additional time delay (Parameter Additional time delay)

After pickup the time value T_{inv} is calculated for every input voltage less than the dropout value. An integrator accumulates the value $1/T_{inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The stage operates after the additional time delay.

The inverse-time delay is calculated with the following formula:

$$T_{inv} = T_p\left(\frac{k}{1-\left(\frac{V}{V_{Thresh}}\right)^{\alpha}}+c\right)$$

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (Parameter Time dial)
V	Measured undervoltage
V_{Thresh}	Threshold value (Parameter Threshold)
k	Curve constant k (Parameter Charact. constant k)
α	Curve constant α (Parameter Charact. constant α)
c	Curve constant c (Parameter Charact. constant c)

The inverse-time characteristic is shown in the following figure:

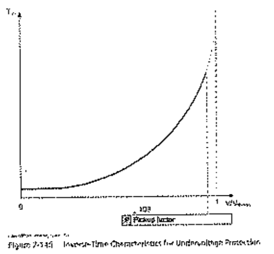


Figure 7-145 Inverse-Time Characteristics for Undervoltage Protection

Pickup Delay

The Pickup delay parameter is only available and of relevance if you are using the current flow criterion of the function (parameter Current-flow criterion = on).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the Pickup delay parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Dropout Behavior

When the voltage exceeds the dropout value (1.05 x pickup factor x threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter Reset time. Instantaneous reset takes place by setting Reset time to 0 s. A delayed reset takes place by setting the desired delay time.

During the Reset time (> 0 s), the elapsed operate delay is frozen. If the stage picks up again within this period, the stage operates when the rest of operate delay expires.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The Current-flow criterion works across all tripping stages.

When the Current-flow criterion parameter is activated, the undervoltage-protection stages only pick up if a settable minimum current (Threshold I>) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to fulfilled with the binary input signal >Current flow-criterion. The function reports when the current-flow criterion is fulfilled.

Figure 7-142 illustrates the influence of the current-flow criterion.

NOTE

If the (_:2311:104) Current-flow criterion parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked-up stage is 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. 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 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.

7.16.8 Application and Setting Notes

Parameter: Pickup mode

- Recommended setting value (_:101) Pickup mode = 1 out of 3

With the Pickup mode parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (1 out of 3) or when there is a lower threshold-value violation in all 3 measuring elements (3 out of 3).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends 1 out of 3 as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting (_:102) Pickup delay = no

The Pickup delay parameter is only available if you are using the current-flow criterion of the function (parameter Current-flow criterion = on). If the current flow criterion is deactivated, no pickup delay is required.

With the parameter Pickup delay, you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for undervoltage pickup and the current flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.

Parameter Value	Description
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting (_:103) Charact. constant k = 1.00
- Default setting (_:104) Charact. constant α = 1.000
- Default setting (_:105) Charact. constant c = 0.000

With the Charact. constant k, Charact. constant α, and Charact. constant c parameters, you define the required inverse-time characteristic.

Parameter: Time dial

- Default setting (_:106) Time dial = 1.00

With the Time dial parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the Time dial parameter at 1.00 (default setting).

Parameter: Reset time

- Default setting (_:109) Reset time = 0.00 s

With the Reset time parameter, you define the reset time delay which is started when the voltage exceeds the dropout value. Set the parameter Reset time to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the Reset time to an appropriate value > 0 s to ensure the operation. Otherwise, Siemens recommends to keep the default value to ensure a fast reset of the function.

Parameter: Additional time delay

- Default setting (_:107) 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, only the inverse-time delay is operative.

7.16.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:10	Inverse-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.

Addr.	Parameter	C	Setting Options	Default Setting
_:101	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:102	Inverse-T #:Pickup delay		• no • yes	no
_:3	Inverse-T #:Threshold		0.300 V to 175.000 V	80.000 V
_:109	Inverse-T #:Pickup factor		0.80 to 1.00	0.90
_:103	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:104	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:105	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:106	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:107	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:108	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

7.16.10 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

337

7.17 Undervoltage Protection with Any Voltage

7.17.1 Overview of Functions

The function Undervoltage protection with any voltage (ANSI 27) detects any 1-phase undervoltage and is intended for special applications.

7.17.2 Structure of the Function

The Undervoltage protection with any voltage function is used in protection function groups, which are based on voltage measurement.

The function Undervoltage protection with any voltage comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current flow criterion can act on all undervoltage protection stages (see Figure 7-146).

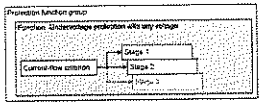


Figure 7-146 Structure/Embedding of the Function

7.17.3 Stage Description

Logic of a Stage

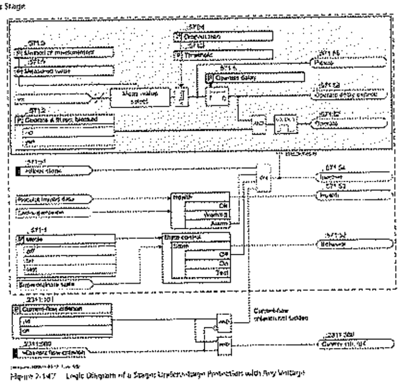


Figure 7-147 Logic Diagram of a Stage: Undervoltage Protection with Any Voltage

NOTE

If the function is used in 1-phase function groups, the parameter Measured value is not available.

Method of Measurement

The Method of measurement parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter Measured value allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function is used in 1-phase function groups, the parameter Measured value is not available.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the Current-flow criterion parameter is switched on, the undervoltage-protection stages only pick up when the current-flow criterion has been set to fulfilled via the binary input signal >Current flow criterion. The function reports when the current-flow criterion is fulfilled.

Figure 7-147 illustrates the influence of the current-flow criterion.

NOTE

If the (_:2311:101) Current-flow criterion parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal >Block stage.

7.17.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:571:8) Method of measurement = fundamental comp.

Use the Method of measurement parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the threshold value of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting (_:571:9) Measured value = VA measured

The Measured value parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the Appendix.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (VA measured)
- Measured phase-to-ground voltage V_B (VB measured)
- Measured phase-to-ground voltage V_C (VC measured)
- Measured phase-to-phase voltage V_{AB} (VAB measured)

- Measured phase-to-phase voltage V_{BC} (VBC measured)
- Measured phase-to-phase voltage V_{CA} (VCA measured)
- Measured voltage VN (VN measured)
- Measured phase-to-phase voltage V_{AB} (VAB calculated)
- Measured phase-to-phase voltage V_{BC} (VBC calculated)
- Measured phase-to-phase voltage V_{CA} (VCA calculated)
- Calculated voltage V0 (V0 calculated)

The selection depends on the corresponding application.

NOTE

If the function is used in 1-phase function groups, the parameter Measured value is not available.

Parameter: Threshold

- Default setting (_:571:3) Threshold = 75 V

Specify the Threshold (pickup threshold) for the specific application.

Depending on the Measured value, the Threshold is set either as measured voltage or as a phase-to-phase variable.

Parameter: Operate delay

- Default setting (_:571:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:571:4) Dropout ratio = 1.05

The recommended set value of 1.05 is appropriate for most applications. To achieve high measurement precision, the Dropout ratio can be reduced to 1.02, for example.

Parameter: Current-flow criterion

- Recommended setting value (_:2311:101) Current-flow criterion = on

Parameter Value	Description
on	Because of the application, it makes sense that the stage is only active (that is, not blocked) when a certain current flow is present (see note).
off	Current-flow monitoring does not make sense for the application.

NOTE

Because of the flexible setting options of the voltage measurand, the function itself does not determine the current associated with the voltage. A suitable current-flow monitoring function must be created by the user with the Continuous Function Chart (CFC) and connected to the binary input signal >Current-flow criterion.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

7.17.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Current flow criterion		• off • on	on
Stage 1				
_:571:1	Stage 1:Mode		• off • on • test	off
_:571:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:571:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VN measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:571:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:571:3	Stage 1:Threshold		0.300 V to 340.000 V	80.000 V
_:571:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05
_:571:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:572:1	Stage 2:Mode		• off • on • test	off
_:572:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:572:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VN measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:572:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:572:3	Stage 2:Threshold		0.300 V to 340.000 V	65.000 V
_:572:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_:572:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

7.17.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:571:81	Stage 1:>Block stage	SPS	I
_:571:54	Stage 1:Inactive	SPS	O
_:571:52	Stage 1:Behavior	ENS	O
_:571:53	Stage 1:Health	ENS	O
_:571:55	Stage 1:Pickup	ACD	O
_:571:56	Stage 1:Operate delay expired	ACT	O
_:571:57	Stage 1:Operate	ACT	O
Stage 2			
_:572:81	Stage 2:>Block stage	SPS	I
_:572:54	Stage 2:Inactive	SPS	O
_:572:52	Stage 2:Behavior	ENS	O
_:572:53	Stage 2:Health	ENS	O
_:572:55	Stage 2:Pickup	ACD	O
_:572:56	Stage 2:Operate delay expired	ACT	O
_:572:57	Stage 2:Operate	ACT	O

335

7.18 Overfrequency Protection

7.18.1 Overview of Functions

The **Overfrequency protection** function (ANSI 81O):

- Detect overfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Disconnect generating units when the power frequency is critical
- Provide additional turbine protection if the speed limiter fails

Frequency deviations are caused by an unbalance between the active power generated and consumed. Over frequency is caused by load shedding (island network), power system disconnection or disturbances of the frequency controller. Overfrequency implies a risk of self-excitation of machines which are connected to long lines without load.

Overfrequency protection is available in two functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

7.18.2 Structure of the Function

The **Overfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The overfrequency protection function comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters Dropout differential and Minimum voltage are set for all stages.

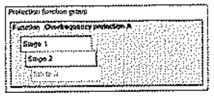


Figure 7-148 Structure/Embedding of the Function

7.18.3 Overfrequency-Protection Stage

Logic of a Stage

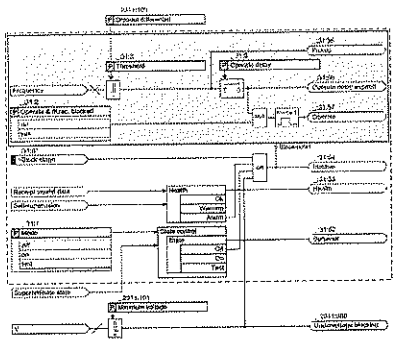


Figure 7-149 Logic Diagram of the Overfrequency Protection Stage

Frequency-Measurement Method

Overfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency measurement method in dependence of the application.

- Angle-difference method (method A):
  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.
- Filtering method (method B):
  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage

Both methods of measurement are characterized by a high measuring accuracy combined with a short pickup time. Disturbance values such as harmonics, high-frequency disturbances, phase-angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.

Functional Measured Value

The angle-difference method provides the following measured value:

Value	Description
f	Calculated frequency with the angle-difference method

Behavior on Leaving the Operating Range

The sampling frequency tracking makes an additional frequency operating range possible. If the stage has picked up before leaving the frequency-operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

Blocking will cause a tripping stage that has picked up to dropout. The following blocking options are available for the stages:

- Externally or internally via the logical binary input >Block stage
- Internally when the voltage drops below the Minimum voltage

7.18.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a 2-out-of-2 decision by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Frequency-Measurement Method	Description
Angle-difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value (_:31:3) Threshold = 51.50 Hz for f_{rated} = 50 Hz

The Threshold parameter is used to define the pickup threshold of the overfrequency protection stage in dependence of the application. 51.50 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value (_:31:6) Operate delay = 10 s

The Operate delay parameter is used to set the stage so that overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value (_:2311:101) Minimum voltage = 37.5 V

For the Undervoltage blocking, 65 % of the protected object's rated voltage is recommended.

When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value (_:2311:109) Dropout differential = 20 mHz

Due to the high-precision frequency measurement, the recommended setting value for the Dropout differential can remain at 20 mHz. For a later dropout of the stage, increase the setting value of the dropout differential. For example, if the pickup value (parameter Threshold) of the stage is set to 51.5 Hz and the Dropout differential to 100 mHz, the stage will drop out at 51.4 Hz.

Setting example of the overfrequency protection for generators

If the overspeed limiter does not function properly, the overfrequency protection issues an additional alarm indication. Overspeeding can be caused by load shedding or by a malfunction of the speed limiter (for example, in an island network).

One possible frequency limit could be 1.03 f_{rated}. If the machine does not recover, it can be shut down with a 2nd stage at, for example, 1.08 f_{rated}. To avoid overfunctions, you can set a sufficient time delay for the warning indication or tripping.

For this application, 2 stages of the overfrequency protection are used. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1>	Warning or disconnection	51.50 Hz	61.80 Hz	20.00
f2>	Shutdown	54.00 Hz	64.80 Hz	5.00

NOTE

The table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

7.18.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:31:1	Stage 1:Mode		• off • on • test	off
_:31:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:31:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	1.00 Hz
_:31:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:32:1	Stage 2:Mode		• off • on • test	off
_:32:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:32:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	1.00 Hz
_:32:6	Stage 2:Operate delay		0.00 s to 600.00 s	5.00 s

7.18.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:31:81	Stage 1:>Block stage	SPS	I
_:31:54	Stage 1:Inactive	SPS	O
_:31:52	Stage 1:Behavior	ENS	O
_:31:53	Stage 1:Health	ENS	O
_:31:55	Stage 1:Pickup	ACD	O
_:31:56	Stage 1:Operate delay expired	ACT	O
_:31:57	Stage 1:Operate	ACT	O
Stage 2			
_:32:81	Stage 2:>Block stage	SPS	I
_:32:54	Stage 2:Inactive	SPS	O
_:32:52	Stage 2:Behavior	ENS	O
_:32:53	Stage 2:Health	ENS	O
_:32:55	Stage 2:Pickup	ACD	O
_:32:56	Stage 2:Operate delay expired	ACT	O
_:32:57	Stage 2:Operate	ACT	O

7.19 Underfrequency Protection

7.19.1 Overview of Functions

The **Underfrequency protection** function (ANSI 81U) is used to:

- Detect underfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Decouple power systems
- Load shedding to ensure power system stability and protect motors
- Disconnect generating units when the power system frequency is critical (for example, f < 0.95 f_{rated})

Frequency deviations are caused by an unbalance between the active power generated and consumed. Under frequency is caused by an increase of the consumers' active power demand or by a decrease of the power generation. These conditions occur in the case of power system disconnection, generator failure, or disturbances of the power and frequency controller.

Underfrequency protection is available in 2 functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

7.19.2 Structure of the Function

The **Underfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The Underfrequency protection function comes with 3 factory-set stages. A maximum of 5 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters Dropout differential and Minimum voltage are set for all stages.

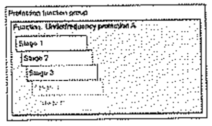


Figure 7-150 Structure/Embedding of the Function

336

7.19.3 Underfrequency-Protection Stage

Logic of a Stage

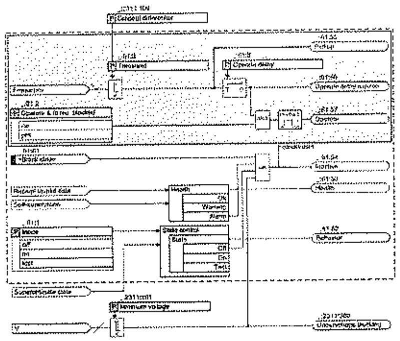


Figure 7-151 Logic Diagram of the Underfrequency Protection Stage

Frequency-Measurement Method

Underfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency-measurement method in dependence of the application.

- Angle-difference method (method A):
  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.
- Filtering method (method B):
  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency-protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage

Both methods of measurement are characterized by a high measuring accuracy combined with a short response time. Disturbance values such as harmonics, high-frequency disturbances, phase-angle jumps during switching operations and commutation processes due to power swings are effectively suppressed.

Behavior on Leaving the Operating Range

The operating frequency tracking makes an additional frequency-operating range possible. If the stage has picked up before leaving the frequency-operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

Blocking will cause a tripping stage that has picked up to drop out. The following blocking options are available for the stage:

- Via the binary input signal >Block stage from an external or internal source
- Internally when the voltage drops below the Minimum voltage

7.19.4 Application and Setting Notes

Reading: Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. Redundant solutions can be implemented by combining 2 different frequency measurement methods. You can implement a 2-out-of-2 decision by linking the pickup indications of both functions in CFC with a logical AND gate. This increases the reliability of protection.

Method of Measurement	Description
Angle-difference method (functional configuration A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (functional configuration B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value (_:61:3) Threshold = 49.80 Hz for f_{rated} = 50 Hz

The Threshold parameter is used to define the pickup threshold of the underfrequency protection stage in dependence of the application. 49.8 Hz is a typical warning threshold in 50 Hz systems.

Parameter: Operate delay

- Recommended setting value (_:61:6) Operate delay = 10 s

The Operate delay parameter is used to set the stage so that overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value (_:2311:101) Minimum voltage = 37.5 V

For the Undervoltage blocking, 65 % of the protected object's rated voltage is recommended. When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value (_:2311:109) Dropout differential = 20 mHz

For a precise frequency measurement, the default setting value for the Dropout differential can be left at 20 mHz. For a later dropout of the stage, increase the setting value of the dropout differential. For instance,

if the pickup value (parameter Threshold) of the stage is set to 49.8 Hz and the Dropout differential to 100 mHz, the stage will drop out at 49.9 Hz.

Setting example of the underfrequency protection for generators

Underfrequency protection provides an additional protection for the turbine. It has the task of ensuring the demand of the power plant system by a timely decoupling from the electrical power system. After the decoupling from the electrical power system, the turbine controller sets the generator unit to the rated speed. Turbogenerators can operate permanently at as little as 95 % of the rated frequency. This requires the apparent power to be reduced by the same factor. A decrease of the frequency leads not only to a higher current consumption by the inductive loads but is also a hazard to stable operation.

This enables the supply of power plant's own system to continue at rated frequency. The decoupling from the electrical power system is initiated without delay at 0.95 f_{rated}. After the decoupling, the generating unit has to ... In the turbine, underfrequency can lead to resonances and inadmissible strains of the turbine blades. You can delay the tripping in order to give the speed controllers sufficient time for a response.

The frequency value to be set depends on the specifications of the power plant operator or the turbine manufacturer (typical setting). It is approx. 0.94 f_{rated}.

For this application, 3 stages of the underfrequency protection are used. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		f at f_{rated} = 50 Hz	f at f_{rated} = 60 Hz	Delay
f<	Warning	49.50 Hz	59.50 Hz	20.00 s
f<<	Decoupling from power system	47.50 Hz	57.50 Hz	0.00 s
f<<<	Shutdown	47.00 Hz	56.40 Hz	10.00 s

NOTE
This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application and the turbine.

7.19.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:61:1	Stage 1:Mode		• off • on • test	off
_:61:2	Stage 1:Operate & fl.rec. blocked		• no • yes	no
_:61:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	[illegible]
_:61:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:62:1	Stage 2:Mode		• off • on • test	off
_:62:2	Stage 2:Operate & fl.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:62:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	[illegible]
_:62:6	Stage 2:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 3				
_:63:1	Stage 3:Mode		• off • on • test	off
_:63:2	Stage 3:Operate & fl.rec. blocked		• no • yes	no
_:63:3	Stage 3:Threshold		40.00 Hz to 70.00 Hz	[illegible]
_:63:6	Stage 3:Operate delay		0.00 s to 600.00 s	10.00 s

7.19.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:61:81	Stage 1:>Block stage	SPS	I
_:61:54	Stage 1:Inactive	SPS	O
_:61:52	Stage 1:Behavior	ENS	O
_:61:53	Stage 1:Health	ENS	O
_:61:55	Stage 1:Pickup	ACD	O
_:61:56	Stage 1:Operate delay expired	ACT	O
_:61:57	Stage 1:Operate	ACT	O
Stage 2			
_:62:81	Stage 2:>Block stage	SPS	I
_:62:54	Stage 2:Inactive	SPS	O
_:62:52	Stage 2:Behavior	ENS	O
_:62:53	Stage 2:Health	ENS	O
_:62:55	Stage 2:Pickup	ACD	O
_:62:56	Stage 2:Operate delay expired	ACT	O
_:62:57	Stage 2:Operate	ACT	O
Stage 3			
_:63:81	Stage 3:>Block stage	SPS	I
_:63:54	Stage 3:Inactive	SPS	O
_:63:52	Stage 3:Behavior	ENS	O
_:63:53	Stage 3:Health	ENS	O
_:63:55	Stage 3:Pickup	ACD	O
_:63:56	Stage 3:Operate delay expired	ACT	O
_:63:57	Stage 3:Operate	ACT	O

7.20 Rate of Frequency Change Protection

7.20.1 Overview of Functions

The function Rate of frequency change protection is used to:

- Detect a frequency change quickly
- Prevent the system from not secure states caused by unbalance between the generated and consumed active power
- Network decoupling
- Load shedding

7.20.2 Structure of the Function

The function Rate of frequency change protection can be used in protection function groups containing a 3-phase voltage measurement.

2 function block types are available:

- df/dt rising
- df/dt falling

The function Rate of frequency change protection is preconfigured by the manufacturer with 1 df/dt rising stage and 1 df/dt falling stage. A maximum of 5 df/dt rising stages and 5 df/dt falling stages can operate simultaneously within the function. Both of the function block types are similar in structure.

Undervoltage check and df/dt calculation are general functionalities and take place on the function level. All stages use these general functionalities.

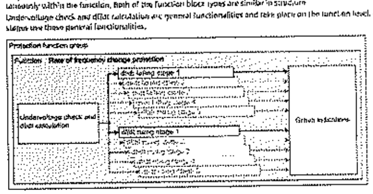


Figure 7-152 Structure/Embedding of the Function

7.20.3 General Functions (Undervoltage Test, df/dt Calculation)

7.20.3.1 Description

Logic

The following figure represents the logic of undervoltage check and df/dt calculation. It applies to all types of stages.

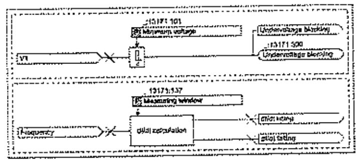


Figure 7-153 Logic Diagram of General Functionality

Measurand

This function uses the frequency calculated via the angle difference algorithm.

For more information, refer to chapter 7.18.3 Overfrequency-Protection Stage.

The frequency difference is calculated over a settable time interval (default setting: 5 periods).

The ratio between the frequency difference and the time difference reflects the frequency change which can be positive or negative.

A stabilization counter works to avoid overfunction. This counter is increased if the set threshold value is exceeded. If the value drops below the threshold value, the counter is reset immediately. The counter is set to 0 normally and is evaluated at each half system cycle.

Undervoltage Blocking

If the measuring voltage drops below the Minimum voltage, the Rate of frequency change protection is blocked because precise frequency values cannot be calculated anymore.

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

7.20.3.2 Application and Setting Notes

Parameter: Minimum voltage

- Recommended setting value (_:13171:101) Minimum voltage = 37.500 V

For the Undervoltage blocking, 65 % of the rated voltage of the protected object is recommended. The method of measurement uses the phasor of the positive-sequence voltage. When determining the setting value, keep in mind that the absolute value of the positive-sequence voltage is equal to the absolute value of the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Measuring window

- Default setting (_:13171:137) Measuring window = 5 periods

You can use the Measuring window parameter to optimize the measuring accuracy or the pickup time of the function. For information regarding pickup time and measuring accuracy, refer to the technical data. The default setting provides maximum measuring accuracy. If you do not have specific requirements for a decreased pickup time, Siemens recommends using the default setting.

337

The default setting is a reasonable compromise between measuring accuracy and pickup time. For a more sensitive setting (high threshold value), you can set the parameter Measuring window to a smaller value.

7.20.4 Stage Description

7.20.4.1 Description

Logic of the Stage

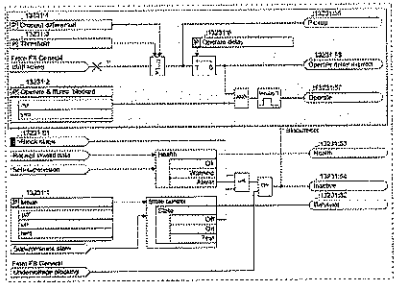


Figure 7-154 Logic Diagram of Rate of Frequency Change Protection

(1) For the stage type df/dt rising, the value df/dt rising is used.

Frequency Rising/Falling

The stage df/dt falling is used to detect frequency falling and the stage df/dt rising is used to detect frequency rising.
You set the threshold value as an absolute value. You define the frequency-change direction via the selected stage type.

Blocking of the Stage

The following blockings reset the picked up stage completely.

- Via the binary input signal >Block stage
- Via the undervoltage blocking when the voltage drops below the Minimum voltage

7.20.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting (_:13231:3) Threshold = 3.0 Hz/s

The pickup value depends on the application and is determined by power-system conditions. In most cases, a network analysis will be necessary. A sudden disconnection of loads leads to a surplus of active power. The frequency rises and causes a positive frequency change. On the other hand, a failure of generators leads to a deficit of active power. The frequency drops and results in a negative frequency change.

The following relations can be used as an example for estimation. They apply for the change rate at the beginning of a frequency change (approximately 1 s).

$$\frac{df}{dt} = \frac{f_{rated}}{2H} \cdot \frac{\Delta P}{S_{rated}}$$

Where:

f_{rated}	Rated frequency
ΔP	Active power change
	$\Delta P = P_{consumption} - P_{generation}$
S_{rated}	Rated apparent power of the machines
H	Inertia constant

Typical data for H:

For hydro generators (salient-pole machines)	H = 1.5 s to 6 s
For turbine-driven generators (non salient pole rotors)	H = 2 s to 10 s
For industrial turbine driven generators	H = 3 s to 4 s

EXAMPLE

f_{rated} = 50 Hz
H = 3 s
Case 1: $\Delta P/S_{rated}$ = 0.12
Case 2: $\Delta P/S_{rated}$ = 0.48
Case 1: df/dt = -1 Hz/s
Case 2: df/dt = -4 Hz/s

Parameter: Operate delay

- Default setting (_:13231:6) Operate delay = 1.00 s

You can use the Operate delay parameter to avoid overfunction due to disturbing influences (for example, switching operations). If the protection function is supposed to respond quickly, set the Operate delay parameter to 0 s.
For monitoring small changes (< 1 Hz/s), a small time delay is useful to avoid overfunctioning.

Parameter: Dropout differential

- Recommended setting value (_:13231:4) Dropout differential = 0.10 Hz/s

You can use the Dropout differential parameter to define the dropout value. The recommended value is 0.10 Hz/s.

NOTE

In case of power-system incidents, especially in case of transmission incidents and influence of voltage-stabilizing measures via power electronic components (reactive-power compensation through SVC), the magnitude and the phase angle of the voltage can change. Sensitive settings can lead to malfunction. Therefore, it is reasonable to block the Rate of Frequency Change Protection if other protection functions, for example, residual voltage or negative-sequence voltage, pick up. To do this, use the blocking input >Block stage and connect it via CFC.

7.20.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13171:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:13171:137	General:Measuring window		2 periods to 5 periods	5 periods
df/dt falling1				
_:13231:1	df/dt falling1:Mode		• off • on • test	off
_:13231:2	df/dt falling1:Operate & flt.rec. blocked		• no • yes	no
_:13231:3	df/dt falling1:Threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:13231:4	df/dt falling1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13231:6	df/dt falling1:Operate delay		0.00 s to 60.00 s	1.00 s
df/dt rising1				
_:13201:1	df/dt rising1:Mode		• off • on • test	off
_:13201:2	df/dt rising1:Operate & flt.rec. blocked		• no • yes	no
_:13201:3	df/dt rising1:Threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:13201:4	df/dt rising1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13201:6	df/dt rising1:Operate delay		0.00 s to 60.00 s	1.00 s

7.20.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:13171:300	General:Undervoltage blocking	SPS	O
_:13171:301	General:df/dt	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
df/dt falling1			
_:13231:81	df/dt falling1:>Block stage	SPS	I
_:13231:54	df/dt falling1:Inactive	SPS	O
_:13231:52	df/dt falling1:Behavior	ENS	O
_:13231:53	df/dt falling1:Health	ENS	O
_:13231:55	df/dt falling1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:13231:56	df/dt falling1:Operate delay expired	ACT	O
_:13231:57	df/dt falling1:Operate	ACT	O
df/dt rising1			
_:13201:81	df/dt rising1:>Block stage	SPS	I
_:13201:54	df/dt rising1:Inactive	SPS	O
_:13201:52	df/dt rising1:Behavior	ENS	O
_:13201:53	df/dt rising1:Health	ENS	O
_:13201:55	df/dt rising1:Pickup	ACD	O
_:13201:56	df/dt rising1:Operate delay expired	ACT	O
_:13201:57	df/dt rising1:Operate	ACT	O

7.21 Power Protection (P,Q), 3-Phase

7.21.1 Overview of Functions

The 3-phase power protection (P, Q) function (ANSI 32) is used for:

- Detect whether the active or reactive power rises above or drops below a set threshold
- Monitor agreed power limits and output warning indications
- Detect both active and reactive power feedback in the power systems or on electric machines
- Detect machines (motors, generators) running without load and output an indication to shut them down.
- Be integrated into any automation solution, for example, to monitor very specific power limits (further logical processing in CFC)

7.21.2 Structure of the Function

The 3-phase power protection (P, Q) function can be integrated in function groups, which provide measured voltages and currents of the 3-phases for calculation of the power.
The 3-phase power protection (P,Q) function comes with one factory-set stage each for the active and the reactive power. The following stages are preconfigured:

- Power P>
- Power Q>
- Power P<
- Power Q<

A maximum of 4 active power stages and 4 reactive power stages can be operated simultaneously in the function. The tripping stages have an identical structure.

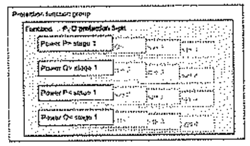


Figure 7-155 Structure/Embedding of the Function

Logical Combination of Output Signals

The operate indications of the active and reactive power stage(s) can be logically combined in CFC. When an operate indication is present in both the active and the reactive power stage, an alarm indication is generated.

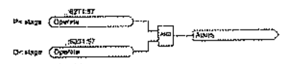


Figure 7-156 Logical Combination of Operate Indications in CFC

7.21.3 Active Power Stage

Logic of a Stage

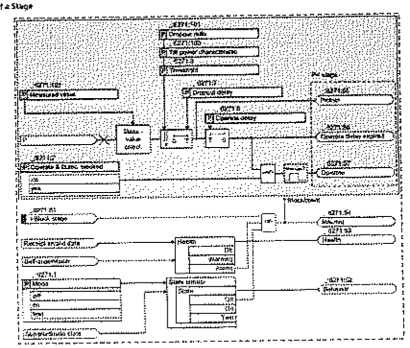


Figure 7-157 Logic Diagram of the Active Power Stage (Stage Type: Power P>)

Measured Value

The Measured value parameter is used to specify which measured power value is analyzed by the tripping stage. Possible settings are power total (neg.: power) and the phase selective powers power of phase A, power of phase B or power of phase C.

Pickup Characteristic

With the stage type you specify if the stage work as a greater stage (stage type: Power P>) or as a smaller stage (stage type: Power P<).

338

The Threshold parameter is used to define the pickup threshold of the stage. The Tilt power characteristic parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.

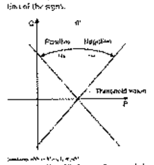


Figure 7-158 Tilt Power Characteristic

Pickup

The stage compares the selected power value with the set Threshold. Depending on the stage type (Power P> or Power P<) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter Operate delay) continues to run. Once the Operate delay has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal >Block stage.

7.21.4 Reactive Power Stage

Logic of a Stage

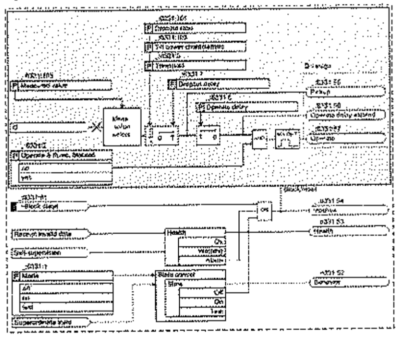


Figure 7-159 Logic Diagram of the Reactive Power Stage (Stage Type: Power Q<)

Measured Value

The Measured value parameter is used to specify which measured power value is processed by the tripping stage. Possible settings are positive seq. power and the phase-selective powers power of phase A, power of phase B or power of phase C.

Pickup Characteristic

With the stage type you specify if the stage works as a greater stage (stage type: Power Q>) or as a smaller stage (stage type: Power Q<).

The Threshold parameter is used to define the pickup threshold of the stage. The Tilt power characteristic parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.

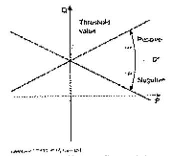


Figure 7-160 Tilt Power Characteristic

Pickup

The stage compares the selected power value with the set Threshold. Depending on the stage type (Power Q> or Power Q<) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter Operate delay) continues to run. Once the Operate delay has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal >Block stage.

7.21.5 Application Example

The setting of the function will be explained using an active/reactive power range as an example. If the apparent power phasor is within the power range (in Figure 7-161 tripping zone defined by characteristics), an alarm indication is generated. For this purpose, you have to make an AND operation of the stage indications of the active and reactive power stage in CFC. The function used is 3-phase power measurement. Figure 7-161 shows the threshold values and the location of the characteristics in the PQ diagram.

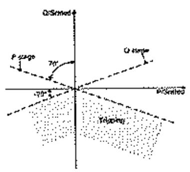


Figure 7-161 Pickup Values and Characteristic Curves

7.21.6 Setting Notes for the Active Power Stage

Stage Type

In the following example, a drop of the active power below a threshold is to be monitored. In the 3-phase circuit breaker (P, Q) function, work with the stage type Power P<.

Parameter: Measured value

- Recommended setting value (_:6271:105) Measured value = positive seq. power

The Measured value parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value (_:6271:3) Threshold = 0 %

The Threshold parameter is used to define the pickup threshold of the active power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter Threshold to 0%.

NOTE

If you use several settings groups, consider the following:

- The dropout value of a stage must have the same sign in all settings groups.
- Switching from a positive dropout value to a negative dropout value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the dropout value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value (_:6271:101) Dropout ratio = 1.05

A hysteresis of 5 % is sufficient for most applications. The setting value for the lower stage is therefore 1.05.

Parameter: Tilt power characteristic

- Recommended setting value (_:6271:102) Tilt power characteristic = +70°

The Tilt power characteristic parameter is used to incline the pickup characteristic. In the above example, an inclination is required. The setting value is +70° (for a definition of the sign, see Figure 7-158).

Parameter: Dropout delay

- Recommended setting value (_:6271:7) Dropout delay = 20 ms

The Dropout delay parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value (_:6271:6) Operate delay = 100 ms

The Operate delay must be set for the specific application. In the example, a setting value of 100 ms has been selected.

7.21.7 Setting Notes for the Reactive Power Stage

Stage Type

In the example, the reactive power is to be monitored if it falls below the threshold. In the 3-phase circuit breaker (P, Q) function, work with the stage type Power Q<.

Parameter: Measured value

- Recommended setting value (_:6331:105) Measured value = positive seq. power

The Measured value parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value (_:6331:3) Threshold = 0 %

The Threshold parameter is used to define the pickup threshold of the reactive power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter Threshold to 0%.

NOTE

If you use several settings groups, consider the following:

- The dropout value of a stage must have the same sign in all settings groups.
- Switching from a positive dropout value to a negative dropout value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
- If you want to change the sign of the dropout value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value (_:6331:101) Dropout ratio = 0.95

A hysteresis of 5 % is sufficient for most applications. The setting value for the lower stage is therefore 0.95.

Parameter: Tilt power characteristic

- Recommended setting value (_:6331:102) Tilt power characteristic = +20°

The Tilt power characteristic parameter is used to incline the pickup characteristic. In the example (see Figure 7-161), the power characteristic has a tilt of 20°. Set the Tilt power characteristic parameter to +20° (for a definition of the sign, see Figure 7-160).

Parameter: Dropout delay

- Recommended setting value (_:6331:7) Dropout delay = 20 ms

The Dropout delay parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value (_:6331:6) Operate delay = 100 ms

The Operate delay must be set for the specific application. In the example, a setting value of 100 ms has been selected.

7.21.8 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Power P> 1				
_:6241:1	Power P> 1:Mode		• off • on • test	off
_:6241:2	Power P> 1:Operate & flt.rec. blocked		• no • yes	no
_:6241:104	Power P> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6241:3	Power P> 1:Threshold		-200.0 % to 200.0 %	80.0 %
_:6241:101	Power P> 1:Dropout ratio		0.90 to 0.99	0.95
_:6241:103	Power P> 1:Tilt power characteristic		-89.0° to 89.0°	0.0°
_:6241:7	Power P> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6241:6	Power P> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power P< 1				
_:6271:1	Power P< 1:Mode		• off • on • test	off
_:6271:2	Power P< 1:Operate & flt.rec. blocked		• no • yes	no
_:6271:105	Power P< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6271:3	Power P< 1:Threshold		-200.0 % to 200.0 %	5.0 %
_:6271:101	Power P< 1:Dropout ratio		1.01 to 1.10	1.05
_:6271:103	Power P< 1:Tilt power characteristic		-89.0° to 89.0°	0.0°

339

Addr.	Parameter	C	Setting Options	Default Setting
_:6271:104	Power Pr 1:Pickup delay		• no • yes	yes
_:6271:7	Power Pr 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6271:6	Power Pr 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q> 1				
_:6301:1	Power Q> 1:Mode		• off • on • test	off
_:6301:2	Power Q> 1:Operate & flt.rec. blocked		• no • yes	no
_:6301:105	Power Q> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6301:3	Power Q> 1:Threshold		-200.0 % to 200.0 %	70.0 %
_:6301:101	Power Q> 1:Dropout ratio		0.90 to 0.99	0.95
_:6301:103	Power Q> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6301:7	Power Q> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6301:6	Power Q> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q< 1				
_:6331:1	Power Q< 1:Mode		• off • on • test	off
_:6331:2	Power Q< 1:Operate & flt.rec. blocked		• no • yes	no
_:6331:105	Power Q< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6331:3	Power Q< 1:Threshold		-200.0 % to 200.0 %	-80.0 %
_:6331:101	Power Q< 1:Dropout ratio		1.01 to 1.10	1.05
_:6331:103	Power Q< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6331:104	Power Q< 1:Pickup delay		• no • yes	yes
_:6331:7	Power Q< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6331:6	Power Q< 1:Operate delay		0.00 s to 60.00 s	1.00 s

7.21.9 Information List

No.	Information	Data Class (Type)	Type
Power Pr 1			
_:6241:81	Power Pr 1:>Block stage	SPS	I
_:6241:54	Power Pr 1:Inactive	SPS	O
_:6241:52	Power Pr 1:Behavior	ENS	O
_:6241:53	Power Pr 1:Health	ENS	O
_:6241:55	Power Pr 1:Pickup	ACD	O
_:6241:56	Power Pr 1:Operate delay expired	ACT	O

No	Information	Data Class (Type)	Type
_:6241:57	Power Pr 1:Operate	ACT	O
Power Pr 2			
_:6271:81	Power Pr 1:>Block stage	SPS	I
_:6271:54	Power Pr 1:Inactive	SPS	O
_:6271:52	Power Pr 1:Behavior	ENS	O
_:6271:53	Power Pr 1:Health	ENS	O
_:6271:55	Power Pr 1:Pickup	ACD	O
_:6271:56	Power Pr 1:Operate delay expired	ACT	O
_:6271:57	Power Pr 1:Operate	ACT	O
Power Q> 1			
_:6301:81	Power Q> 1:>Block stage	SPS	I
_:6301:54	Power Q> 1:Inactive	SPS	O
_:6301:52	Power Q> 1:Behavior	ENS	O
_:6301:53	Power Q> 1:Health	ENS	O
_:6301:55	Power Q> 1:Pickup	ACD	O
_:6301:56	Power Q> 1:Operate delay expired	ACT	O
_:6301:57	Power Q> 1:Operate	ACT	O
Power Q< 1			
_:6331:81	Power Q< 1:>Block stage	SPS	I
_:6331:54	Power Q< 1:Inactive	SPS	O
_:6331:52	Power Q< 1:Behavior	ENS	O
_:6331:53	Power Q< 1:Health	ENS	O
_:6331:55	Power Q< 1:Pickup	ACD	O
_:6331:56	Power Q< 1:Operate delay expired	ACT	O
_:6331:57	Power Q< 1:Operate	ACT	O

7.22 Phase-Rotation Reversal

7.22.1 Overview of Functions

The Phase-sequence switchover function enables correct execution of the protection of the device and supervision functions, independently of the phase sequence in a system or system section.

The phase sequence is set via parameters. You can select between the phase sequences ABC or ACB. Binary inputs provide the option of switching over the phase sequence contrary to the parameter setting. By changing over the phase sequence you temporarily change the direction of rotation in motors for example.

The phase sequence has an effect on calculation of the positive-sequence system and negative-sequence system values and on calculation of phase-to-phase values. A phase-rotation reversal therefore has an effect on all protection and supervision functions that use these values.

You can change the phase sequence in 2 ways via binary inputs:

- Change over the phase sequence for the entire device.
  In doing so, all 3-phase measuring points are switched over. All analog inputs are therefore affected (for example, current and voltage inputs simultaneously).
- Changing over the phase sequence per measuring point.
  In doing so, only the activated measuring points are switched over. The other measuring points remain unaffected.

7.22.2 Structure of the Function

The Phase-sequence switchover function is integrated in the Power-system data. You will find the signals in the DIGSI 5 project tree under Name of the device → Parameters. There you will find the parameter for setting the phase sequence and the binary inputs via which you can influence a change in the phase sequence.

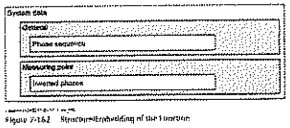


Figure 7-162 Structure/Embedding of the Function

7.22.3 Function Description

General

The phase sequence of the system is set in the device via the **Phase sequence** parameter. You will find the signals in the DIGSI 5 project tree under **Name of the device** → **Parameters** → **Power-system data** → **General**. There are 2 methods to change the phase sequence for different operational requirements.

- With the binary signal *>Phs-rotation reversal* you change over the phase sequence at all measuring points.
- With the binary signal *>Invert Phases* you change over the phase sequence per measuring point. The *Inverted phases* parameter available per measuring point is used to set which phases at the measuring point must be swapped. The parameter can be found at each 3-phase measuring point.

The two mechanisms are explained separately below.

Switchover of the Phase Sequence of All Measuring Points

The direction of rotation of the currents and voltages depends on the phase sequence. The following drawing shows the vector definitions for the 2 phase sequences.

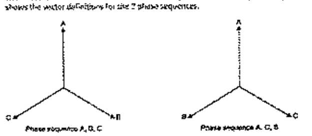


Figure 7-163 Vector with Different Phase Sequences

The phase sequence of a system or a system section is defined when parameterizing via the Phase sequence parameter. The setting parameter acts on all measuring points.

The operationally induced switchover between the phase sequence ABC and the phase sequence ACB is initiated via the binary input >Invert Phases. This switches over the phase sequence simultaneously at all 3-phase measuring points.

The following image shows a logic diagram for determining the current phase assignment and switchover. The indication, shown on the right, show the present phase sequence. If the phase sequence is set via the Phase sequence parameter to ABC, the activation of the binary input will result in a switchover in the phase sequence ACB.

The switchover of the phase sequence is only authorized for a time at which no measured values are pending. The switchover command must be present for at least 200 ms. The change of phase sequence is only permissible when the machine is at standstill. If the current and voltage values of all 3-phase measuring points are below 5 % of the nominal variable, this is recognized as machine standstill.

A renewed machine standstill must be detected for a resetting of the phase sequence in the set preferred position.

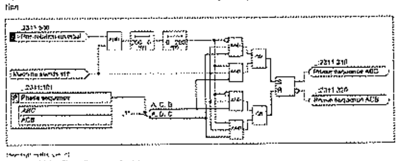


Figure 7-164 Phase Sequence Switchover

Changing Over the Phase Sequence per Measuring Point

A switchover of the phase sequence per measuring point can also be necessary for operational reasons. This switchover enables proper performance of the protection devices at the transition from generator operation to motor operation (pump operation).

The following example shows an application in a pumped storage plant. The switchover of the phase sequence (change in rotational direction) realizes the transition there from generator operation to motor operation. Which phases and measuring points are changed over depends on the conditions in the system.

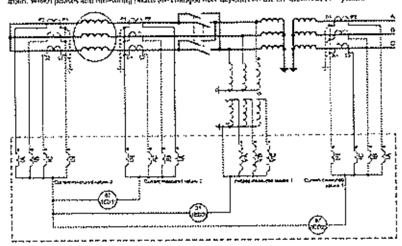


Figure 7-165 Application Example for Phase-Rotation Reversal in a Pump Station

The example shows 2 differential protection devices (IED1 and IED2) and an impedance protection (IED3) with the connected measuring points.

The phase sequence is insignificant for the differential protection of IED1, as the protected object is not affected by the switchover option of the phase sequence.

The phase sequence is also relevant to the differential protection of IED2, as the protected object extends beyond the switchover option.

The phase sequence is also relevant to the impedance protection (IED3). Depending on the switch position, the voltage measured values 1 and the current measured values 3 have a different phase sequence.

The phase sequence of the system is set in the device via the **Phase sequence** parameter for generator operation. The *Inverted phases* parameter is used to set which phase is swapped for the relevant measuring point. The swap is communicated to the measuring point via the binary input signal *>Invert Phases*. The changed phase sequence is then included for calculation of the measurands at the measuring point.

In accordance with Figure 7-165, the phase sequence is set to ABC. A is swapped with C in motor operation. The *Inverted phases* parameter must be set to AC for the current measured values 2 and current measured values 3 measuring points. As a result, the phase assignment for the differential protection IED2 and the impedance protection IED3 is correct. The positive sequence and negative-sequence current is calculated correctly.

The following logic diagram shows the principle for determining the present phase assignment and measured variables with the example of currents.

The switchover of the phase sequence is only authorized for a time at which no measured values are pending. The switchover command must be present for at least 200 ms. The change of phase sequence is only permissible when the machine is at standstill. In doing so, the system checks for the measuring point to be switched over whether the measured variables are below 5 % of the nominal variables. If the currents of the measuring points (current measured values 2 and current measured values 3 in the example) fall below 5 % of their nominal variables, machine standstill is detected.

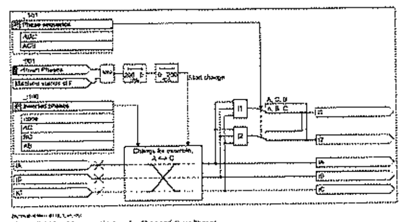


Figure 7-166 Measured Values for Changed-Over Phases

7.22.4 Application and Setting Notes

Parameter: Phase sequence

- Default setting (_:101) Phase sequence = ABC

ABC	Phase sequence A, B, C
ACB	Phase sequence A, C, B

Parameter: Inverted phases

- Default setting (_:106) Inverted phases = none

none	No phase exchange
AC	Phase A changed over with phase C
BC	Phase B changed over with phase C
AB	Phase A changed over with phase B

Input signal: >Phs-rotation reversal

The binary input >Phs-rotation reversal is used to switch over between the phase sequence ABC and the phase sequence ACB. The switchover direction depends on the setting of the Phase sequence parameter. In doing so, the phase sequence of all 3-phase measuring points is changed.

Input signal: >Invert Phases

The binary input >Invert Phases is used to activate the setting of the parameter Inverted phases. In doing so, the phase sequence at the selected measuring point is changed.

7.22.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	General:Phase sequence		• ABC • ACB	ABC
General				
_:101	VT 3-phase:Rated primary voltage		0.20 kV to 1 200.00 kV	400.00 kV
_:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:104	VT 3-phase:VT connection		• 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
_:105	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:111	VT 3-phase:Tracking		• inactive • active	active
_:107	VT 3-phase:Measuring-point ID		0 to 100	0

7.22.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>Phs-rotation reversal	SPS	I
_:501	General:>Invert Phases	SPS	I
General			
_:319	General:Phase sequence ABC	SPS	O
_:320	General:Phase sequence ACB	SPS	O
_:321	General:Freq.out of oper.range	SPS	O
_:322	General:f sys	MV	O
_:323	General:f track	MV	O
General			
_:315	VT 3-phase:Phases AB inverted	SPS	O
_:316	VT 3-phase:Phases BC inverted	SPS	O
_:317	VT 3-phase:Phases AC inverted	SPS	O

7.23 Instantaneous Tripping at Switch onto Fault

7.23.1 Overview of Functions

The Instantaneous tripping at switch onto fault function serves for immediate tripping when switching onto a fault.

The function does not have its own measurement and must be linked to another protection function with the pickup (measurement).

7.23.2 Structure of the Function

The function is preconfigured with a stage. A maximum of 2 tripping stages can be operated simultaneously in the function. The stages have an identical structure.

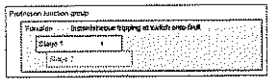


Figure 7-167 Structure/Embedding of the Function

7.23.3 Stage Description

Logic of the Stage

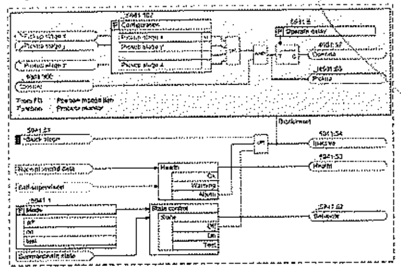


Figure 7-168 Logic Diagram of the Stage Instantaneous Tripping at Switch onto Fault

Connection of the Stage

The stage is intended to initiate instantaneous tripping when switching onto a fault. To do this, the stage must be connected to one or more pickups from protection functions or protection stages, for example, to pickup of an overcurrent protection stage. That is, the stage of the Instantaneous tripping at switch onto fault function does not have its own measuring function but requires the pickup of another protection function or protection stage to pick up.

The stage is active only if switching is pending or executed (for this, see section).

NOTE

If the pickup of a protection stage takes place and tripping is blocked by the Inrush-current detection function, no pickup of the Instantaneous tripping at switch onto fault function takes place. In this case, there is no fault recording neither. Despite this, if a fault recording is necessary, you can activate it with the parameter (_:114) Start flt.rec. of the Inrush-current detection function (see chapter 7.10 Inrush-Current Detection).

7.23.4 Application and Setting Notes

Parameter: Configuration

- Default setting (_:5941:102) Configuration = no stage

The Configuration parameter is used to define with which pickup of a protection function or protection stage the Instantaneous tripping at switch onto fault function responds.

Normally, the pickups of protection functions and stages with high fault current are selected:

- Overcurrent protection (phase and ground)

A specific protection stage is generally used. This can be one of the protection stages provided for the protection application, which itself trips with a delay. An additional protection stage with settings optimized for this use case, for example, increased threshold value and blocking of self-tripping, can also be used.

Parameter: Operate delay

- Recommended setting value (_:5941:6) Operate delay = 0.00 s

When switching onto a fault, the tripping should usually be instantaneous. The tripping delay is therefore set to 0.

7.23.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:5941:1	Stage 1:Mode		• off • on • test	off
_:5941:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:5941:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s
_:5941:102	Stage 1:Configuration		Setting options depend on configuration	

7.23.6 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			
_:5941:81	Stage 1:>Block stage	SPS	I
_:5941:54	Stage 1:Inactive	SPS	O
_:5941:52	Stage 1:Behavior	ENS	O
_:5941:53	Stage 1:Health	ENS	O
_:5941:55	Stage 1:Pickup	ACD	O
_:5941:57	Stage 1:Operate	ACT	O

7.24 Negative-Sequence Protection

7.24.1 Overview of Functions

The function **Negative-sequence protection** (ANSI 46):

- Detects 1-phase or 2-phase short circuits in the electrical power system with clearly increased sensitivity compared to the classical overcurrent protection
- Protects electric machines during excessive unbalanced load
- Reports unbalanced load conditions in the electricity supply system
- Detects phase interruptions in the primary system
- Locates short circuits or inversions at the connections to the current transformers

7.24.2 Structure of the Function

The **Negative-sequence protection** function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 2 **Definite-time negative-sequence protection** stages.

In the function **Negative-sequence protection**, the following stages can be operated simultaneously:

- 3 stages **Definite-time negative-sequence protection**
- 2 stages **Inverse-time negative-sequence protection**

The stages have an identical structure. Stages that are not preconfigured are shown in gray in the following figure.

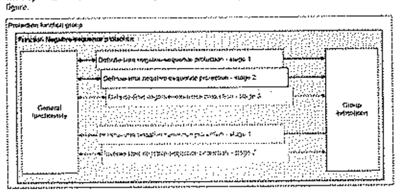


Figure 7-169 Structure/Embedding of the Function

If the device is equipped with the Inrush-current detection function, the stages can be stabilized against operate due to transformer-inrush currents.

7.24.3 Stage Description

Logic of a Stage

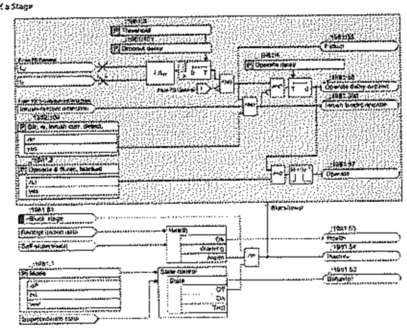


Figure 7-170 Logic Diagram of the Stage Negative-Sequence Protection with Definite-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3 phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the **FB General**.

Blocking of the Stage

When blocked, the picked-up protection stage will drop out.

In addition to the current blocking (see Current limitation Imax and Maximum phase current), the stages can be blocked in the following ways:

- Via the binary input signal >Block stage from an external or internal source
- When leaving the permissible frequency operating range

371

7.24.4 Application and Setting Notes

Parameter: Threshold

- Recommended setting value (_:1981:3) Threshold = 10 %

The setting of the parameter Threshold depends on the respective application. A threshold value of 10 % is a practicable value for fault indications of electrical machines.

Parameter: Operate delay

- Recommended setting value (_:1981:6) Operate delay = 1500 ms

The setting of the Operate delay depends on the application. Observe the time grading in the power system protection and do not set the time for monitoring too short. The default setting is practicable. For motors, the time depends on the permissible time period for the set unbalanced load.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:1981:104) Blk. w. inrush curr. detect. = no

With the parameter Blk. w. inrush curr. detect., the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to yes.

7.24.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:106	General:Reference value		• pos. seq. current • rated current	rated current
_:2311:107	General:Current limitation Imax		• no • yes	no
_:2311:101	General:Maximum phase current	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
_:2311:104	General:Release current	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 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
Definite-T 1				
_:1981:1	Definite-T 1:Mode		• off • on • test	off
_:1981:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:1981:3	Definite-T 1:Threshold		5.0 % to 999.9 %	10.0 %
_:1981:4	Definite-T 1:Dropout ratio		0.40 to 0.99	0.95
_:1981:104	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:1981:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1981:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.50 s
Definite-T 2				
_:1982:1	Definite-T 2:Mode		• off • on • test	off
_:1982:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:1982:3	Definite-T 2:Threshold		5.0 % to 999.9 %	65.0 %
_:1982:4	Definite-T 2:Dropout ratio		0.40 to 0.99	0.95
_:1982:104	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:1982:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1982:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

7.24.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:Overcurrent blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:1981:81	Definite-T 1:>Block stage	SPS	I
_:1981:52	Definite-T 1:Behavior	ENS	O
_:1981:53	Definite-T 1:Health	ENS	O
_:1981:54	Definite-T 1:Inactive	SPS	O
_:1981:56	Definite-T 1:Operate delay expired	ACT	O
_:1981:300	Definite-T 1:Inrush blocks operate	ACT	O
_:1981:55	Definite-T 1:Pickup	ACD	O
_:1981:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:1982:81	Definite-T 2:>Block stage	SPS	I
_:1982:52	Definite-T 2:Behavior	ENS	O
_:1982:53	Definite-T 2:Health	ENS	O
_:1982:54	Definite-T 2:Inactive	SPS	O
_:1982:56	Definite-T 2:Operate delay expired	ACT	O
_:1982:300	Definite-T 2:Inrush blocks operate	ACT	O
_:1982:55	Definite-T 2:Pickup	ACD	O
_:1982:57	Definite-T 2:Operate	ACT	O

7.24.7 Description

Logic of a Stage

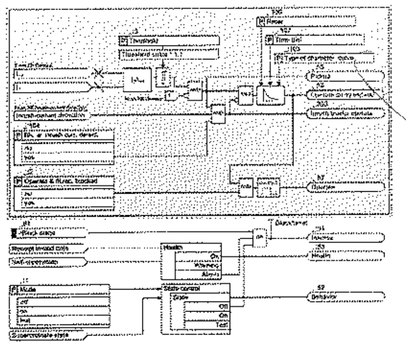


Figure 7-171 Logic Diagram of the Negative-Sequence Protection with Inverse-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the FB General.

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 stage picks up, and 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 a factor of 0.95 (0.95 · 1.1 · threshold value), the dropout is started. The pickup is 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.

Blocking of the Stage

When blocked, the picked-up protection stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal >Block stage.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

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 time delay and tripping are however blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

7.24.8 Application and Settings Notes

Parameter: Type of character. curve

- Default setting (_: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 11.33 Stage with Inverse-Time Characteristic Curve.

Parameter: Threshold

- Recommended setting value (_:3) Threshold = 10.0 %

The setting of the parameter Threshold depends on the respective application. A threshold value of 10 % is a practicable value for fault detection for different applications.

Parameter: Time dial

- Recommended setting value (_:107) Time dial = 1.00

With the parameter Time dial, you displace the characteristic curve in the time direction.

The set value for the parameter Time dial is derived from the time-grading schedule 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 1.00 (default setting).

Parameter: Reset

- Default setting (_:106) Reset = disk emulation

With the parameter Reset, you 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: Blk. w. inrush curr. detect.

- Default setting (_:104) Blk. w. inrush curr. detect. = no

With the parameter Blk. w. inrush curr. detect., the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to yes.

7.24.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:3	Inverse-T #:Threshold		5.0 % to 999.9 %	10.0 %
_:104	Inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:105	Inverse-T #:Type of character. curve		[illegible]	[illegible]
_:106	Inverse-T #:Reset		• instantaneous • disk emulation	disk emulation
_:107	Inverse-T #:Time dial		0.05 to 15.00	1.00

7.24.10 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:54	Inverse-T #:Inactive	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:300	Inverse-T #:Inrush blocks operate	ACT	O
_:59	Inverse-T #:Disk emulation running	SPS	O
_:55	Inverse-T #:Pickup	ACD	O
_:57	Inverse-T #:Operate	ACT	O

7.25 Thermal Overload Protection, 3-Phase

7.25.1 Overview of Functions

The Thermal overload protection function (ANSI 49) is used to:

- Protect the equipment (motors, generators, transformers, capacitors, overhead lines, and cables) against thermal overloads
- Monitor the thermal state of motors, generators, transformers, capacitors, overhead lines, and cables

7.25.2 Structure of the Function

The Thermal overload protection, 3-phase function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 1 Thermal overload protection stage.

The non-preconfigured function block Filter can optionally be applied to gain the RMS value used by the Thermal overload protection stage.

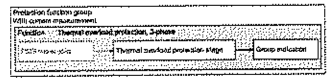


Figure 7-172 Structure/Embedding of the Function

7.25.3 Filter for RMS Value Gain

7.25.3.1 Description

The function block Filter can be used to adjust 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 by the device due to the anti-aliasing filter.

The filter gain (amplitude response) is realized by a 9-order FIR filter.

342

Logic

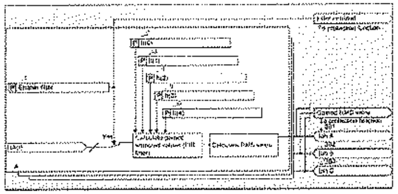


Figure 7-173 Logic Diagram of the Function Block Filter

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 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 this 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	Filtered RMS measured value of current A	kA	A	Parameter Rated current
Iph:B	Filtered RMS measured value of current B	kA	A	Parameter Rated current
Iph:C	Filtered RMS measured value of current C	kA	A	Parameter Rated current

You can find the parameter Rated current in the FB General of function groups where the Thermal overload protection function is used.

If the parameter Enable filter is set to no, the function values are shown as ---.

7.25.3.2 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.

Parameters 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 in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.032 h(1) = -0.012 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.035 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

7.25.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filter				
_: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

7.25.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O

7.25.4 Description

Logic

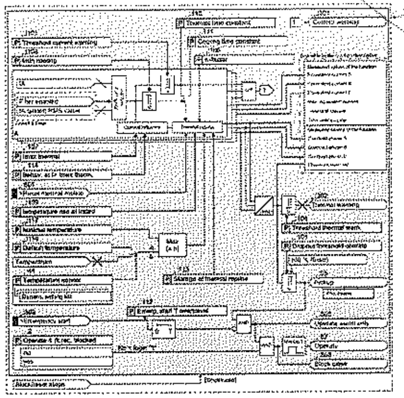


Figure 7-174 Logic Diagram of the Thermal Overload Protection Stage

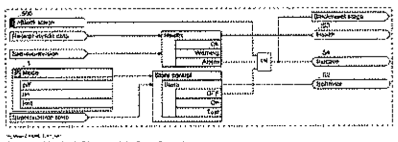


Figure 7-175 Logic Diagram of the Stage Control

RMS-Value Selection

The protection function supports 2 kinds of RMS measurement:

- Normal RMS value
- Gained RMS value from the function block Filter

The gained RMS value is automatically used if the function block Filter is configured and the filter has been enabled.

NOTE

When the function block Filter is applied, only one current measuring point I-3ph is allowed to be connected to the 3-phase current interface of the function group.

Thermal Replica

The protection function calculates the overtemperature from the phase currents based on a thermal single-body model according to the thermal differential equation with

$$\dot{I}^2_{\text{...}} = \tau_{th}\frac{d\theta}{dt} + \theta - \theta_{amb}$$

With the following standardization:

$$I_{\text{...}} = \frac{I}{I_{\text{...}}} = \frac{I}{K \cdot I_{rated,obj}} \quad \theta = \frac{\theta}{\theta_{\text{...}}} = \frac{\theta}{K^2 \cdot \Delta\theta_{rated,obj}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \theta_{Amb} = \frac{\theta_{amb} - 40\,°C}{\theta_{\text{...}}} = \frac{\theta_{amb} - 40\,°C}{K^2 \cdot \Delta\theta_{rated,obj}}$$

θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current $k \cdot I_{rated,obj}$
θ_{Amb}	Standardized ambient temperature, where θ_{amb} describes the coupled ambient temperature. The coupled ambient temperature θ_{amb} can be the measured ambient temperature or the ambient temperature preset using the Default temperature parameter.
$\Delta\theta_{rated,obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object

k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated,obj}$)
$I_{rated,obj}$	Rated current of the protected object

At the same time, $I_{rated,obj}$ is the rated current of the assigned protected object side:

- In the case of transformers, the rated current of the winding to be protected, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- The uncontrolled winding forms the basis in the case of transformers with voltage control
- In the case of generators, motors and reactors, the rated current, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- In the case of lines, nodes and busbars, the rated current of the protected object is set directly

In a steady state, the solution to the thermal differential equation is an e-function whose asymptote represents the final overtemperature θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold θ_{warn} (Threshold thermal warn.), a warning indication is given.

If the overtemperature limit θ_{off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 7-176 shows the temperature rise at different overload currents and the supervision thresholds.

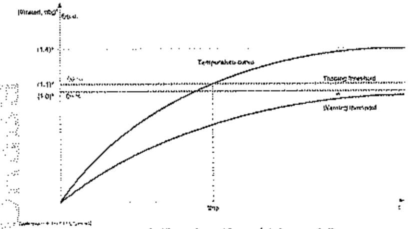


Figure 7-176 Temperature History for Different Overload Currents (K-Factor = 1.1)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

If the flowing current falls below an adjustable minimum current Imin cooling , the Cooling time constant is activated.

Operate Curve

If the ambient temperature is not measured and set to 40°C, you can get the operate curve as following:

$$t = \tau_{th} \cdot \ln\frac{\left(\frac{I}{k \cdot I_{\text{...}}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{\text{...}}}\right)^2}{\left(\frac{I}{k \cdot I_{\text{...}}}\right)^2 - 1}$$

t	Operate time
τ_{th}	Time constant
I	Measured load current
$I_{preload}$	Preload current
k	Setting factor according to VDE 0435 part 3011 or IEC 60255-8 (k factor)
$I_{rated,obj}$	Rated current of the protected object

Ambient Temperature

This function can take the ambient temperature into consideration. The reference temperature of the thermal model is 40°C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The Default temperature parameter can be used to fix or measure the ambient temperature. The Minimal temperature parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter Temperature rise at Irated).

The measured ambient temperature is measured by an external RTD unit (RTD – Resistance Temperature Detector) and provided by the function: RTD unit Ether. or RTD unit serial of the function group Analog transformer. When using the Temperature sensor parameter, the respective temperature sensor can be selected.

If the temperature measurement is faulty, for example, due to an open circuit between the device and the RTD unit, the device reports this. In this case, the process continues with either the temperature measured last or the value set under the Default temperature parameter, depending on which value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding $I_{\text{...}}$). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby retarded at high currents

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal K-factor of 1.1 , a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. The current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

343

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the Dropout threshold operate, the trip command is canceled upon tripping. In contrast, the current warning threshold and the thermal warning threshold are reset at a fixed dropout threshold (see Technical Data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary voltage failure via the setting parameter Storage of thermal replica. You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication >Reset thermal replica. The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal >Emergency start, tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input >Emergency start disappears, the blocking remains in effect for the set Emerg. start T overtravel.

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal >Block stage.

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal Block close can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and canceled if the temperature falls below the dropout threshold.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

7.25.5 Application and Setting Notes

Parameter: Threshold current warning

- Recommended setting value (_:101) Threshold current warning = 1.1 A at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max, perm}$). This results in the same setting value as for the K-factor.

Parameter: Threshold thermal warn.

- Recommended setting value (_:104) Threshold thermal warn. = 90 %

The default setting can be left at a K-factor of 1.1, as the thermal memory settles for 83 % of continuously flowing rated current. The calculation uses the rule of three. 100 % corresponds to $I_{K\text{-factor}}^2$ and x % corresponds to I^2:

$$\frac{x}{\Theta_{\ddot{u}}} = \frac{100\ \%}{k^2} = 83\ \%$$

At a K-factor of 1.05, the thermal memory for rated current is already 91 % filled. Increase the Threshold thermal warn. to 95 %.

Parameter: Dropout threshold operate

- Recommended setting value (_:105) Dropout threshold operate = 90 %

The Dropout threshold operate parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, demand additional cooling or longer blocking of closing.

Note that the calculation of the operational measured value Time until close refers to this value.

Parameter: Emerg. start T overtravel

- Default setting (_:112) Emerg. start T overtravel = 300 s

This functionality is not required for protection of lines and cables. If the logical binary indication is not routed, the Emerg. start T overtravel will be ineffective. The Emerg. start T overtravel presetting can therefore be retained.

Parameter: K-factor

- Recommended setting value (_:106) K-factor = 1.1

The K-factor parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated, obj}$ of the protected object (for example, cable) is the basic current for overload sensing. You can determine the K-factor on the basis of the thermally permissible continuous current $I_{max, perm}$:

$$\text{K-factor} = \frac{I_{max,perm}}{I_{setting}}$$

> **NOTE**
> The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer!

In the case of cables, the permissible continuous current depends on the cross-section, insulation material, design type, and the manner in which the cables have been laid. In the case of overhead lines, an overload of 10 % is permissible.

EXAMPLE

For the Permissible Continuous Current

Cross-linked polyethylene cables (N2XS2Y) 10 kV 150 mm² (Cu)

Current-carrying capacity (underground laying): $I_{max,perm}$ = 406 A

Selected K-factor of 1.1

This yields a rated current of $I_{rated,obj}$ = 369 A

Parameter: Thermal time constant

- Recommended setting value (_:110) Thermal time constant = 2777 s (46.29 min)

The Thermal time constant parameter is used to define the tripping characteristics of the stage. If no data on the Thermal time constant is available, you can determine this from the short-time current-carrying capacity of the cable, for example, from the 1 s current. The 1 s current is the maximum current permissible for 1 s application time. The 1 s current can be found in the cable specifications. Calculate the Thermal time constant according to the following formula:

$$\tau[\text{min}] = \frac{1}{60} \cdot \left(\frac{\text{perm. 1-s-current}}{\text{perm. continuous current}}\right)^2$$

If the short-term current rating capacity is specified for an application time other than 1 s, use the short-time current instead of the 1-s current. Multiply the result by the specified application time.

For a given short-term current carrying capacity of 0.5 s, use the following formula:

$$\tau[\text{min}] = \frac{0.5}{60} \cdot \left(\frac{\text{perm. 0.5-s-current}}{\text{perm. continuous current}}\right)^2$$

EXAMPLE for a Cable

For a cable:

Permissible continuous current: $I_{max,perm}$ = 406 A

Maximum short-circuit current for 1 s: I_{1s} = 21.4 kA

Therefore, for the Thermal time constant, it follows:

$$\tau\ [\text{min}] = \frac{1}{60} \cdot \left(\frac{21400\ \text{A}}{406\ \text{A}}\right)^2 = \frac{1}{60} \cdot 52.7^2 = 46.29\ \text{min}$$

with 46.29 min = 2777 s

Parameter: Cooling time constant

- Recommended setting value (_:111) Cooling time constant = 2777 s

The Cooling time constant parameter is used to define the dropout behavior of the stage. Cables and overhead lines have the same time constant for both heating and cooling. Therefore, set the same value for the Cooling time constant as for the parameter Thermal time constant.

Parameter: Imax thermal

- Recommended setting value (_:107) Imax thermal = 2.5 A at I_{rated} = 1 A

The Imax thermal parameter allows you to set the threshold current for the Behav. at I> Imax therm. parameter. The selected threshold current of 2.5 $I_{rated, obj}$ is a practicable value.

Parameter: Imin cooling

- Recommended setting value (_:108) Imin cooling = 0 A

If only the thermal time constant (parameter Thermal time constant) must provide protection, set the current parameter Imin cooling to 0 A.

Parameter: Temperature rise at Irated

- Default setting (_:109) Temperature rise at Irated = 70 K

As a value, set the overtemperature that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the technical data of the equipment or measure it. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40°C.

The overtemperature at maximum permissible current (Θmax) and the Temperature rise at Irated (Θrated, obj.) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\Theta_{max}}{\Delta\Theta_{rated,obj}}\right)$$

EXAMPLE:

Temperature class B for continuous operation: permissible overtemperature = 80 K

From this, a temperature for I_{rated} of 120°C (80 K + 40°C) can be derived when using a temperature sensor for the measurement.

Temperature class F as thermal limiting value: permissible overtemperature = 105 K

From this, a maximum temperature of 145°C (105 K + 40°C) derives.

From these values, the K-factor can be derived:

$$k^2 = \frac{\Delta\Theta_{max,Obj}}{\Delta\Theta_{rated,Obj}} = \frac{105\ \text{K}}{80\ \text{K}} = 1.31 \quad \rightarrow \quad k = 1.146$$

If you select a setting value of 1.1 for the K-factor, your selection can be considered as conservative.

> **NOTE**
> For electrical machines, the limits can vary depending on the type of coolant.
> Consult the machine manufacturer to agree on a setting value for the overtemperature.

Parameter: Storage of thermal replica

- Recommended setting value (_:113) Storage of thermal replica = no

If a continuous auxiliary voltage for the bay units is ensured, the bay default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value (_:114) Behav. at I> Imax therm. = freeze therm. rep.

The Behav. at I> Imax therm. parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified.

The default setting has been selected to be compatible with SIPROTEC 4 devices. If you wish to take further temperature rise into consideration, the current limiting procedure is recommended.

Parameter Value	Description
freeze therm. rep.	If input currents exceed the Imax thermal parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products!
current limiting	The input currents are limited to the value set in the Imax thermal parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An adjustable current threshold is approx. 2 to 2.5 $I_{rated, obj}$.

Parameter: Temperature sensor

- Default value (_:44) Temperature sensor = none

With the Temperature sensor parameter, you determine which temperature sensor to use to detect the ambient temperature.

A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and feed it to the device via an RTD unit. The Thermal overload protection function receives the measured temperature value via the functions RTD unit Ether. or RTD unit Serial from the function group Analog transformer.

Parameter: Default temperature

- Recommended setting value (_:118) Default temperature = 40°C

The Default temperature is set as ambient temperature under the following conditions:

- No temperature sensor for measuring the ambient temperature is connected.
- The temperature measurement is faulty and the last measured temperature value is less than the Default temperature.

Siemens recommends using the default setting.

Parameter: Minimal temperature

- Default setting (_:117) Minimal temperature = -20°C

If the measured ambient temperature drops below the set value, the set value is assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the Minimal temperature parameter, the Minimal temperature is also used.

7.25.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:101	49 Th.overl. #:Threshold current warning	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
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:112	49 Th.overl. #:Emerg. start T overtravel		0 s to 15000 s	300 s
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:111	49 Th.overl. #:Cooling time constant		10 s to 60000 s	3600 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:108	49 Th.overl. #:Imin cooling	1 A @ 100 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	2.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:118	49 Th.overl. #:Default temperature		-55°C to 55°C	40°C
_:117	49 Th.overl. #:Minimal temperature		-55°C to 40°C	-20°C
_:44	49 Th.overl. #:Temperature sensor		Setting options depend on configuration	

7.25.7 Information List

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:81	49 Th.overl. #:Mode (controllable)	ENC	C
_:500	49 Th.overl. #:>Block stage	SPS	I

344

No.	Information	Data Class (Type)	Type
_:301	49 Th.overl. #:>Reset thermal replica	SPS	I
_:302	49 Th.overl. #:>Emergency start	SPS	I
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload phase A	MV	O
_:307	49 Th.overl. #:Overload phase B	MV	O
_:308	49 Th.overl. #:Overload phase C	MV	O
_:309	49 Th.overl. #:Overload maximum	MV	O
_:310	49 Th.overl. #:Equival. current phs A	MV	O
_:311	49 Th.overl. #:Equival. current phs B	MV	O
_:312	49 Th.overl. #:Equival. current phs C	MV	O
_:313	49 Th.overl. #:Equival. current max	MV	O

7.26 Thermal Overload Protection, 1-Phase

7.26.1 Overview of Functions

The Thermal overload protection 1-phase function (ANSI 49) is used to:

- Protect the equipment (reactors or resistors in the neutral point of a transformer) from thermal overload

7.26.2 Structure of the Function

The Thermal overload protection 1-phase function is used in 1-phase protection function groups with current measurement.

The Thermal overload protection, 1-phase function is completely preconfigured.

Protection function group 1-phase with current measurement

Function Thermal overload protection 1-ph.

Figure 7-177 Structure/Embedding of the Function

7.26.3 Function Description

Logic

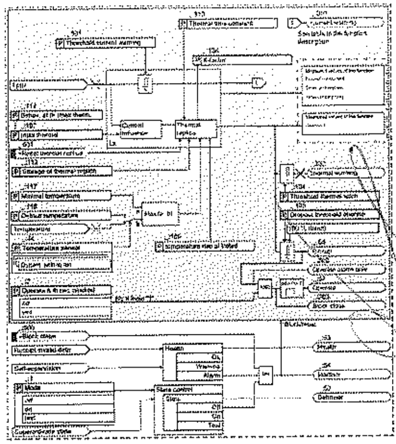


Figure 7-178 Logic Diagram of the Thermal Overload Protection Function

Thermal Replica

The protection function calculates the overtemperature from the current flowing in the protected object (for example, reactor or resistance in the transformer neutral point) on the basis of a thermal single-body model according to the thermal differential equation with

$$\dot{\vartheta}_{H} = \tau_{th}\frac{d\Theta}{dt} + \Theta - \Theta_{u}$$

With the following standardization:

$$\dot{\vartheta}_{H} = \frac{I}{I_{max}} \times \frac{I}{k \cdot I_{rated,obj}} \qquad \Theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{k^2 \cdot \Delta\vartheta_{rated,obj}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \Theta_{u} = \frac{\vartheta_{Amb} - 40\,°C}{\vartheta_{max}} = \frac{\vartheta_{Amb} - 40\,°C}{k^2 \cdot \Delta\vartheta_{rated,obj}}$$

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible current $k \cdot I_{rated,obj}$
Θ_u	Standardized ambient temperature, where ϑ_{Amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{Amb} can be the measured ambient temperature or the ambient temperature preset using the Default temperature parameter.
$\Delta\vartheta_{rated,obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object
k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated,obj}$)
$I_{rated,obj}$	Rated current of the protected object

At the same time, $I_{rated,obj}$ is the rated current of the protected object

In a steady state, the solution to the thermal differential equation is an e function whose asymptote represents the final overtemperature ϑ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (Threshold thermal warn.), a warning indication is given.

If the overtemperature limit Θ_{off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 7-179 shows the temperature rise at different overload currents and the supervision thresholds.

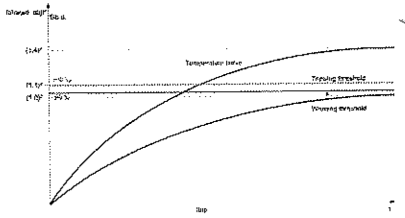


Figure 7-179 Temperature History for Different Overload Currents (K-factor = 1.1)

The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached.

The analysis of the RMS value of the current over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Ambient Temperature

This function can take the ambient temperature into consideration. The reference temperature of the thermal model is 40 °C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The Default temperature parameter can be used to fix or measure the ambient temperature. The Minimal temperature parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter Temperature rise at Irated).

The measured ambient temperature is recorded by an external RTD unit (RTD = Resistance Temperature Detector) and provided by the functions RTD unit Ether. or RTD unit serial of the function group Analog units. When using the Temperature sensor parameter, the respective temperature sensor can be selected. If the temperature measurement is disrupted, for example, due to an open circuit between the device and the RTD unit, the device will report it. In this case, the process continues with either the temperature measured last or the value set under the Default temperature parameter, whichever value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding I_{max}). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby retarded at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal K-factor of 1.1, a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the Dropout threshold operate, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are realized at a fixed dropout threshold (see technical data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary voltage failure via the Storage of thermal replica parameter. You can save the thermal state for a down time of 500 min. If the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication >Reset thermal replica. The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Blocking the Function

Blocking will cause a picked up function to be reset. The function can be blocked externally or internally by the binary input signal >Block stage.

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal Block close can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Measured Value	Description
(_:310) Equivel. current	Besides the thermal measured values in percent, the equivalent current is also issued as a thermal current-measured value (A or kA). The current equivalent is the primary current, which corresponds to the thermal measured value in percent, assuming steady state conditions.
(_:304) Time until close	The Time until close is the expected time until it is possible for the protected object for reclosure. The calculation of this value is based on the assumption of constant currents. The thermal replica has then fallen below the setting value of the dropout threshold.
(_:305) Time until trip	The Time until trip is the expected time until tripping (100 % value exceeded) occurs. The calculation of this value is based on the assumption of constant currents.
(_:306) Overload	The value Overload indicates the current temperature of the protected object in percent. Tripping occurs if 100 % is exceeded.

7.26.4 Application and Setting Notes

Parameter: Threshold current warning

- Recommended setting value (_:102) Threshold current warning = 1.1 A for I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max,prim}$). This results in the same setting value as for K-factor.

Parameter: Threshold thermal warn.

- Recommended setting value (_:104) Threshold thermal warn. = 90 %

The default setting can be left at a K-factor of 1.1, because the thermal memory sets itself to 83 % at continuously flowing rated current. The calculation uses the following: 100 % corresponds to (K-factor)² and x % corresponds to 1².

$$\frac{\Theta}{\Theta_{off}} = \frac{100\,\%}{k^2} = 83\,\%$$

At a K-factor of 1.05, the thermal memory for rated current is 91% (fixed). Increase the Threshold thermal warn. to 95%.

375

Parameter: Dropout threshold operate

- Recommended setting value (_:105) Dropout threshold operate = 90 %

The Dropout threshold operate parameter is used to cancel pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling, or longer blocking of switching on.

The calculation of the operational measured value Time until close refers to this value.

Parameter: K-factor

- Recommended setting value (_:106) K-factor = 1.1

The K-factor parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated,obj}$ of the protected object (for example, resistance) is the basic current for overload sensing.

You can determine K-factor on the basis of the thermally permissible continuous current $I_{max,perm}$:

$$K\text{-factor} = \frac{I_{max,perm}}{I_{rated,obj}}$$

> **NOTE**
> The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer.

Siemens recommends using the default value as it is a typical value for many applications.

Parameter: Thermal time constant

- Default value (_:110) Thermal time constant = 900 s (15 min)

The Thermal time constant parameter is used to define the operate curve of the stage. If no time constant is given, you can derive it from other values.

EXAMPLE

Protection of a current-limiting resistance

Rated current of the resistance: I_{rated} = 100 A

Values for the overload capability:

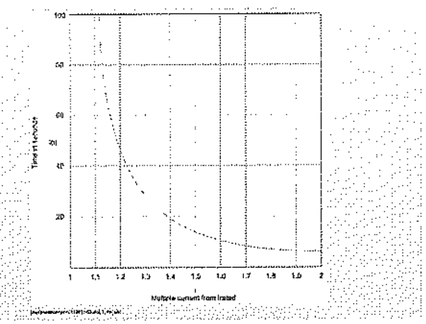
- 1.1 I_{rated} permanent (K-factor = 1.1 (k = 1.1))
- 1.5 I_{rated} for 20 s for charge by cold

The following time constant results from these assumed values:

$$\tau_{th} = t \cdot K \cdot \left[\ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1}\right]^{-1} = 20\ s \cdot \left[\ln \frac{\left(\frac{1.5}{1.1}\right)^2}{\left(\frac{1.5}{1.1}\right)^2 - 1}\right]^{-1} = 20\ s \cdot \left[\ln \frac{1.86}{0.86}\right]^{-1} = 26\ s$$

For Thermal time constant, set 26 s.

The following time-dependent characteristic results from the data. In case of a current increase to 1.5 I_{rated}, the tripping occurs in 20 s.



Parameter: Imax thermal

- Recommended setting value (_:107) Imax thermal = 2.5 A for I_{rated} = 1 A

The Imax thermal parameter allows you to set the threshold current for the Behav. at I> Imax therm. parameter. The selected current threshold of 2.5 $I_{rated,obj}$ is a practicable value.

Parameter: Temperature rise at Irated

- Default setting (_:109) Temperature rise at Irated = 70 K

> **NOTE**
> For an application as a 1-phase overload protection, the ambient temperature measured via the temperature sensor is not taken into account. Therefore, the setting has no influence. You can keep the default setting. If you take into account the temperature, note the following descriptions.

Set the overtemperature as the value that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the Technical data of the equipment or you can measure the value. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40 °C.

The overtemperature at maximum permissible current (Θ_{max}) and the Temperature rise at Irated ($\Theta_{rated,obj.}$) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\Theta_{max}}{\Delta\Theta_{rated,obj}}\right)$$

EXAMPLE:

Temperature class B for continuous operation: permissible overtemperature = 80 K

From this, a temperature for I_{max} of 120 °C (80 K + 40 °C) can be derived when using a measuring element for the measurement.

Temperature class F as thermal limiting value: permissible overtemperature = 105 K.

Thus, a maximum temperature of 145 °C (105 K + 40 °C) derives.

From these values, the magnitude of the K-factor can be derived:

$$k^2 = \frac{\Delta\Theta_{max,obj}}{\Delta\Theta_{rated,obj}} = \frac{105\ K}{80\ K} = 1.31 \rightarrow k = 1.146$$

If selecting a setting value of 1.1 for the K-factor, your selection can be considered as conservative.

Parameter: Storage of thermal replica

- Recommended setting value (_:113) Storage of thermal replica = no

If a continuous auxiliary voltage of the bay unit is ensured, the default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value (_:114) Behav. at I> Imax therm. = current limiting

The Behav. at I> Imax therm. parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified.

The default setting has been selected compatible with SIPROTEC 4 devices. If you wish to take further temperature into consideration, the current limiting procedure is recommended.

Parameter Value	Description
current limiting	The input current is limited to the value set in the Imax thermal parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated,obj}$.
freeze therm. rep.	If the input current exceeds the Imax thermal parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products.

Parameter: Temperature sensor

- Default setting (_:44) Temperature sensor = none

Use the Temperature sensor parameter to determine which temperature sensor to use to detect the ambient temperature.

A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and to feed it to the device via an RTD unit. The function Thermal overload protection receives the measured temperature value via the function RTD unit Ether. or RTD unit Serial from the function group Analog units.

Parameter: Default temperature

- Recommended setting value (_:118) Default temperature = 40°C

Under the following conditions, the Default temperature will be set as ambient temperature:

- A temperature sensor for measuring the ambient temperature is not connected.
- The temperature measurement is interrupted and the measured temperature value is less than the Default temperature.

Siemens recommends using the default setting.

Parameter: Minimal temperature

- Default setting (_:117) Minimal temperature = -20°C

If the measured ambient temperature drops below the preset value, the set value will be assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the Minimal temperature parameter, the Minimal temperature can also be used.

7.26.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no
_:101	49 Th.overl. #:Threshold current warning	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
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:118	49 Th.overl. #:Default temperature		-55°C to 55°C	40°C

Addr.	Parameter	C	Setting Options	Default Setting
_:117	49 Th.overl. #:Minimal temperature		-55°C to 40°C	-20°C
_:44	49 Th.overl. #:Temperature sensor		Setting options depend on configuration	

7.26.6 Information

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:500	49 Th.overl. #:>Block stage	SPS	I
_:501	49 Th.overl. #:>Reset thermal replica	SPS	I
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload	MV	O
_:310	49 Th.overl. #:Equival. current	MV	O

7.27 Temperature Supervision

7.27.1 Overview of Functions

The Temperature supervision function checks the thermal state of:

- Motors
- Generators
- Transformers

In rotating machines, it also checks bearing temperatures for a limit violation.

The temperatures are measured at various locations of the protected object using temperature sensors (RTD = Resistance Temperature Detector) and are sent to the device via one or more RTD units.

The Temperature supervision function receives its measured temperature values via the RTD unit Ether., Serial RTD unit or IO 111 functions from the Analog units function group.

7.27.2 Structure of the Function

The Temperature supervision function can work in all protection function groups. A maximum of 48 temperature supervision locations can operate simultaneously in the Temperature supervision function function. Each temperature supervision location has 2 threshold stages.

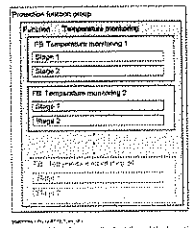


Figure 7-310 Structure/Embedding of the Function

376

7.27.3 Function Description

Logic

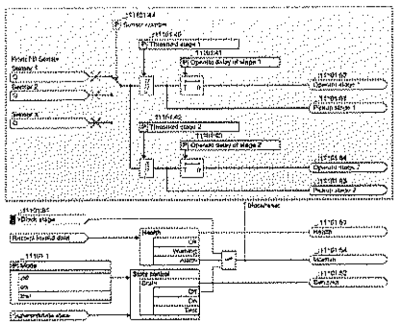


Figure 7-181 Logic Diagram for a Temperature Supervision Location

The **Temperature supervision location** function block (Location FB) receives a measured temperature value in °C or °F as an input variable delivered from the temperature sensor function blocks of the **Analog units** function group. The **Sensor number** parameter is used to select the temperature sensor.

2 threshold value decisions can be performed for each measuring point. If the measured temperature value is greater than or equal to the set threshold values, the stages generate a pickup indication independent of one another and, after a set tripping time delay, an operate indication.

The indications from the supervision locations remain available for further processing.

NOTE

The pickup of the stages does not result in fault logging. The operate indications of the stages do not go into the trip logic of the device.

7.27.4 Application and Setting Notes

If you use an external RTD unit, connect the RTD unit via an interface (Ethernet or serial) to the SIPROTEC 5 device. Observe the setting notes for configuration of the interfaces in chapter Analog Transformer Function Group Type under 3.6.2.2 Communication with an RTD Unit.

Parameter: Sensor location

- Default setting (_:11101:46) Sensor location = Other

You inform the device of the sensor installation location using the Sensor location parameter. Oil, Ambient, Turn, Bearing and Other are available for selection. The selection is not evaluated in the device, it only serves an informational purpose on the medium in which the temperature measurement takes place.

Parameter: Sensor number

- Default setting (_:11101:44) Sensor number = no function block selected

With the Sensor number parameter, you assign a specific sensor whose temperature is to be monitored to the Location function block. You perform the assignment in DIGSI using a list box that contains all connected RTD units and their sensors.

Parameter: Threshold stage 1

- Default setting (_:11101:40) Threshold stage 1 = 100°C

With the Threshold stage 1 parameter you establish the temperature value whose exceedance causes a pickup of the 1st tripping stage.

Parameter: Operate delay of stage 1

- Default setting (_:11101:41) Operate delay of stage 1 = 5 s

With the Operate delay of stage 1 parameter you establish the time the operate indication of the 1st tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Parameter: Threshold stage 2

- Default setting (_:11101:42) Threshold stage 2 = 120°C

With the Threshold stage 2 parameter you establish the temperature value whose exceedance causes a pickup of the 2nd tripping stage.

Parameter: Operate delay of stage 2

- Default setting (_:11101:43) Operate delay of stage 2 = 0 s

With the Operate delay of stage 2 parameter you establish the time the operate indication of the 2nd tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Temperature Unit

Temperature unit to change the display and evaluation of measured temperature values from °C to °F. Adapt the DIGSI user default settings accordingly (see 5.6.7.5 Temperature Sensor).

7.27.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Point 1				
_:11101:46	Point 1:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11101:1	Point 1:Mode		• off • on • test	off
_:11101:40	Point 1:Threshold stage 1		-50°C to 250°C	100°C
_:11101:41	Point 1:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11101:42	Point 1:Threshold stage 2		-50°C to 250°C	120°C
_:11101:43	Point 1:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11101:44	Point 1:Sensor		Setting options depend on configuration	
Point 2				
_:11102:46	Point 2:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11102:1	Point 2:Mode		• off • on • test	off
_:11102:40	Point 2:Threshold stage 1		-50°C to 250°C	100°C
_:11102:41	Point 2:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11102:42	Point 2:Threshold stage 2		-50°C to 250°C	120°C
_:11102:43	Point 2:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11102:44	Point 2:Sensor		Setting options depend on configuration	
Point 3				
_:11103:46	Point 3:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11103:1	Point 3:Mode		• off • on • test	off
_:11103:40	Point 3:Threshold stage 1		-50°C to 250°C	100°C
_:11103:41	Point 3:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11103:42	Point 3:Threshold stage 2		-50°C to 250°C	120°C
_:11103:43	Point 3:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11103:44	Point 3:Sensor		Setting options depend on configuration	
Point 4				
_:11104:46	Point 4:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11104:1	Point 4:Mode		• off • on • test	off
_:11104:40	Point 4:Threshold stage 1		-50°C to 250°C	100°C
_:11104:41	Point 4:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11104:42	Point 4:Threshold stage 2		-50°C to 250°C	120°C
_:11104:43	Point 4:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11104:44	Point 4:Sensor		Setting options depend on configuration	
Point 5				
_:11105:46	Point 5:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11105:1	Point 5:Mode		• off • on • test	off
_:11105:40	Point 5:Threshold stage 1		-50°C to 250°C	100°C
_:11105:41	Point 5:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11105:42	Point 5:Threshold stage 2		-50°C to 250°C	120°C
_:11105:43	Point 5:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11105:44	Point 5:Sensor		Setting options depend on configuration	
Point 6				
_:11106:46	Point 6:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11106:1	Point 6:Mode		• off • on • test	off
_:11106:40	Point 6:Threshold stage 1		-50°C to 250°C	100°C
_:11106:41	Point 6:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11106:42	Point 6:Threshold stage 2		-50°C to 250°C	120°C
_:11106:43	Point 6:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11106:44	Point 6:Sensor		Setting options depend on configuration	
Point 7				
_:11107:46	Point 7:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11107:1	Point 7:Mode		• off • on • test	off
_:11107:40	Point 7:Threshold stage 1		-50°C to 250°C	100°C
_:11107:41	Point 7:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11107:42	Point 7:Threshold stage 2		-50°C to 250°C	120°C
_:11107:43	Point 7:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11107:44	Point 7:Sensor		Setting options depend on configuration	
Point 8				
_:11108:46	Point 8:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11108:1	Point 8:Mode		• off • on • test	off
_:11108:40	Point 8:Threshold stage 1		-50°C to 250°C	100°C
_:11108:41	Point 8:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11108:42	Point 8:Threshold stage 2		-50°C to 250°C	120°C
_:11108:43	Point 8:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11108:44	Point 8:Sensor		Setting options depend on configuration	
Point 9				
_:11109:46	Point 9:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11109:1	Point 9:Mode		• off • on • test	off
_:11109:40	Point 9:Threshold stage 1		-50°C to 250°C	100°C
_:11109:41	Point 9:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11109:42	Point 9:Threshold stage 2		-50°C to 250°C	120°C
_:11109:43	Point 9:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11109:44	Point 9:Sensor		Setting options depend on configuration	
Point 10				
_:11110:46	Point 10:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11110:1	Point 10:Mode		• off • on • test	off
_:11110:40	Point 10:Threshold stage 1		-50°C to 250°C	100°C
_:11110:41	Point 10:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11110:42	Point 10:Threshold stage 2		-50°C to 250°C	120°C
_:11110:43	Point 10:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11110:44	Point 10:Sensor		Setting options depend on configuration	
Point 11				
_:11111:46	Point 11:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11111:1	Point 11:Mode		• off • on • test	off
_:11111:40	Point 11:Threshold stage 1		-50°C to 250°C	100°C
_:11111:41	Point 11:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11111:42	Point 11:Threshold stage 2		-50°C to 250°C	120°C
_:11111:43	Point 11:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11111:44	Point 11:Sensor		Setting options depend on configuration	
Point 12				
_:11112:46	Point 12:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11112:1	Point 12:Mode		• off • on • test	off
_:11112:40	Point 12:Threshold stage 1		-50°C to 250°C	100°C
_:11112:41	Point 12:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11112:42	Point 12:Threshold stage 2		-50°C to 250°C	120°C
_:11112:43	Point 12:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11112:44	Point 12:Sensor		Setting options depend on configuration	

347

7.27.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
Point 1			
_:11101:81	Point 1:>Block stage	SPS	I
_:11101:54	Point 1:Inactive	SPS	O
_:11101:52	Point 1:Behavior	ENS	O
_:11101:53	Point 1:Health	ENS	O
_:11101:61	Point 1:Pickup stage 1	SPS	O
_:11101:62	Point 1:Operate stage 1	SPS	O
_:11101:63	Point 1:Pickup stage 2	SPS	O
_:11101:64	Point 1:Operate stage 2	SPS	O
Point 2			
_:11102:81	Point 2:>Block stage	SPS	I
_:11102:54	Point 2:Inactive	SPS	O
_:11102:52	Point 2:Behavior	ENS	O
_:11102:53	Point 2:Health	ENS	O
_:11102:61	Point 2:Pickup stage 1	SPS	O
_:11102:62	Point 2:Operate stage 1	SPS	O
_:11102:63	Point 2:Pickup stage 2	SPS	O
_:11102:64	Point 2:Operate stage 2	SPS	O
Point 3			
_:11103:81	Point 3:>Block stage	SPS	I
_:11103:54	Point 3:Inactive	SPS	O
_:11103:52	Point 3:Behavior	ENS	O
_:11103:53	Point 3:Health	ENS	O
_:11103:61	Point 3:Pickup stage 1	SPS	O
_:11103:62	Point 3:Operate stage 1	SPS	O
_:11103:63	Point 3:Pickup stage 2	SPS	O
_:11103:64	Point 3:Operate stage 2	SPS	O
Point 4			
_:11104:81	Point 4:>Block stage	SPS	I
_:11104:54	Point 4:Inactive	SPS	O
_:11104:52	Point 4:Behavior	ENS	O
_:11104:53	Point 4:Health	ENS	O
_:11104:61	Point 4:Pickup stage 1	SPS	O
_:11104:62	Point 4:Operate stage 1	SPS	O
_:11104:63	Point 4:Pickup stage 2	SPS	O
_:11104:64	Point 4:Operate stage 2	SPS	O
Point 5			
_:11105:81	Point 5:>Block stage	SPS	I
_:11105:54	Point 5:Inactive	SPS	O
_:11105:52	Point 5:Behavior	ENS	O
_:11105:53	Point 5:Health	ENS	O
_:11105:61	Point 5:Pickup stage 1	SPS	O

No.	Information	Data Class (Type)	Type
_:11105:62	Point 5:Operate stage 1	SPS	O
_:11105:63	Point 5:Pickup stage 2	SPS	O
_:11105:64	Point 5:Operate stage 2	SPS	O
Point 6			
_:11106:81	Point 6:>Block stage	SPS	I
_:11106:54	Point 6:Inactive	SPS	O
_:11106:52	Point 6:Behavior	ENS	O
_:11106:53	Point 6:Health	ENS	O
_:11106:61	Point 6:Pickup stage 1	SPS	O
_:11106:62	Point 6:Operate stage 1	SPS	O
_:11106:63	Point 6:Pickup stage 2	SPS	O
_:11106:64	Point 6:Operate stage 2	SPS	O
Point 7			
_:11107:81	Point 7:>Block stage	SPS	I
_:11107:54	Point 7:Inactive	SPS	O
_:11107:52	Point 7:Behavior	ENS	O
_:11107:53	Point 7:Health	ENS	O
_:11107:61	Point 7:Pickup stage 1	SPS	O
_:11107:62	Point 7:Operate stage 1	SPS	O
_:11107:63	Point 7:Pickup stage 2	SPS	O
_:11107:64	Point 7:Operate stage 2	SPS	O
Point 8			
_:11108:81	Point 8:>Block stage	SPS	I
_:11108:54	Point 8:Inactive	SPS	O
_:11108:52	Point 8:Behavior	ENS	O
_:11108:53	Point 8:Health	ENS	O
_:11108:61	Point 8:Pickup stage 1	SPS	O
_:11108:62	Point 8:Operate stage 1	SPS	O
_:11108:63	Point 8:Pickup stage 2	SPS	O
_:11108:64	Point 8:Operate stage 2	SPS	O
Point 9			
_:11109:81	Point 9:>Block stage	SPS	I
_:11109:54	Point 9:Inactive	SPS	O
_:11109:52	Point 9:Behavior	ENS	O
_:11109:53	Point 9:Health	ENS	O
_:11109:61	Point 9:Pickup stage 1	SPS	O
_:11109:62	Point 9:Operate stage 1	SPS	O
_:11109:63	Point 9:Pickup stage 2	SPS	O
_:11109:64	Point 9:Operate stage 2	SPS	O
Point 10			
_:11110:81	Point 10:>Block stage	SPS	I
_:11110:54	Point 10:Inactive	SPS	O
_:11110:52	Point 10:Behavior	ENS	O
_:11110:53	Point 10:Health	ENS	O
_:11110:61	Point 10:Pickup stage 1	SPS	O
_:11110:62	Point 10:Operate stage 1	SPS	O

No.	Information	Data Class (Type)	Type
_:11110:63	Point 10:Pickup stage 2	SPS	O
_:11110:64	Point 10:Operate stage 2	SPS	O
Point 11			
_:11111:81	Point 11:>Block stage	SPS	I
_:11111:54	Point 11:Inactive	SPS	O
_:11111:52	Point 11:Behavior	ENS	O
_:11111:53	Point 11:Health	ENS	O
_:11111:61	Point 11:Pickup stage 1	SPS	O
_:11111:62	Point 11:Operate stage 1	SPS	O
_:11111:63	Point 11:Pickup stage 2	SPS	O
_:11111:64	Point 11:Operate stage 2	SPS	O
Point 12			
_:11112:81	Point 12:>Block stage	SPS	I
_:11112:54	Point 12:Inactive	SPS	O
_:11112:52	Point 12:Behavior	ENS	O
_:11112:53	Point 12:Health	ENS	O
_:11112:61	Point 12:Pickup stage 1	SPS	O
_:11112:62	Point 12:Operate stage 1	SPS	O
_:11112:63	Point 12:Pickup stage 2	SPS	O
_:11112:64	Point 12:Operate stage 2	SPS	O

7.28 Arc Protection

7.28.1 Overview of Function

The function Arc protection:

- Detects arcs in air-insulated switchgear parts without delay and in a fail-safe way
- Limits system damage through instantaneous high-speed tripping
- Protects systems from thermal overload
- Increases safety of personnel
- Trips in a 3-pole way
- Is suitable for use in all voltage levels

7.28.2 Structure of the Function

The Arc protection function can be added to function groups that provide current measured values.

The Arc protection function consists of the following blocks:

- General
- 3 stages
- Output logic 3-phase

The Arc protection function is preconfigured with 3 stages. A maximum of 12 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The following figure shows the basic structure of the Arc protection function.

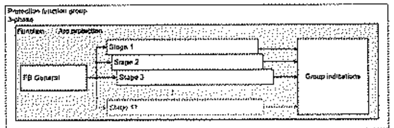


Figure 7-182 Structure/Embedding of the Arc Protection Function

7.28.3 Function Description

General Logic of the Function Block

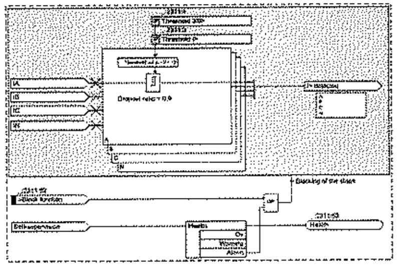


Figure 7-183 General Logic Diagram of the Function Block

Logic of the Stage

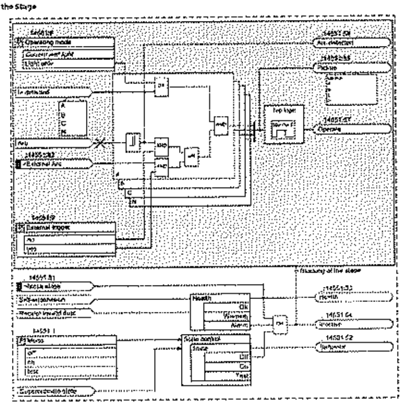


Figure 7-184 Logic Diagram of the Stage

The Arc protection function uses a locally connected optical arc sensor or an external trip initiation by other devices in order to detect arcs.

> **NOTE**
>
> Install the arc sensors inside the switchgear in such a way that they are not hidden behind other system components!
>
> Shadowing of the arc sensors must be avoided!

> **NOTE**
>
> Once an optical sensor has detected an arc, you must replace the affected optical sensor!

378

Within the Arc protection function, you can use a fast current-flow criterion as an additional release criterion. The parameters for the current-flow criterion can be found in the General block. For each stage, you can select individually whether the current-flow criterion must be evaluated as well.

Method of Measurement, Current-Flow Criterion

The current-flow criterion works with 2 different methods of measurement:

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A direct current component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds the threshold value set by the current amount 2 · √2 · threshold value, the stage uses additional unfiltered measurands. Thus, very short operate times are possible.

NOTE

If using the current-flow criterion in addition to the light, prevent a potential overfunction caused by the suddenly occurring light signal.
If you use the current-flow criterion, arcs are typically detected in 4 ms.

Self Monitoring

The Arc protection function uses a self-monitoring circuit. This circuit monitors the optical arc sensors and the fiber-optic cables. The arc-protection module uses the fiber-optic cable to send a cyclic test signal (light) to the arc sensors. If the channel is operating properly, the test signal is sent back to the arc protection module. If the test signal is not returned to the arc protection module, the indication Channel # Sensor failure is generated.
If the self-monitoring function detects a fault, the indication Health is set to Alarm and the stage/function is blocked.

7.28.4 Application and Setting Notes – General Settings

Go to General under the function Arc protection and set the following parameters. The setting values apply to all stages.

Parameter: Threshold I>

- Default setting (_:2311:3) Threshold I> = 2.000 A

Use the parameter Threshold I> to define the trigger threshold of the phase currents. The Threshold I> is relevant for the current-flow criterion of the arc protection function.
Set the Threshold I> of the function Arc protection in such a manner that the RMS value of the inrush current does not exceed the Threshold I> when activating the local circuit breaker.
For more information about how to calculate the setting value, refer to 7.4.4.2 Application and Setting Notes

Parameter: Threshold 3I0>

- Default setting (_:2311:4) Threshold 3I0> = 1.000 A

Use the parameter Threshold 3I0> to determine the tripping threshold for the zero-sequence current. The Threshold 3I0> is relevant for the current-flow criterion of the Arc protection function.
Set the Threshold 3I0> of the function Arc protection in such a manner that the RMS value of the inrush current does not exceed the Threshold 3I0> when activating the local circuit breaker.
For more information about how to calculate the setting value, refer to 7.5.4.2 Application and Setting Notes

NOTE

If you set the parameter CT connection = 3-phase, 2 primary CT for the 3-phase current measuring point, the parameter Threshold 3I0> has no effect.

7.28.5 Application and Setting Notes for the Stage

Parameter: External trip initiation

- Default setting (_:14551:9) External trip initiation = no

Use the parameter External trip initiation to set whether an external input signal is used to trigger the stage.

Parameter Value	Description
no	The stage does not operate with an external input signal.
yes	The stage operates with an external input signal. If the stage operates with an external input signal, the binary-input signal >External Arc must be routed in the DIGSI 5 information routing. In this setting option, the binary input signal >External Arc is only visible in the DIGSI 5 information routing. Note: When working with external trip initiation, do not select a channel. If an additional channel is selected with this setting value, DIGSI 5 will signal an inconsistency.

Parameter: Operating mode

- Default setting (_:14551:8) Operating mode = Current and light

Use the parameter Operating mode to define the basic functionality of the stage.

Parameter Value	Description
Current and light	The stage operates with the input variables current and light. The current-flow criterion ensures that the light signal originates from an arc. Siemens recommends using this setting.
Light only	This stage operates only with the input signal 'light' and is triggered even if current is not measured. This operating mode can cause a overfunction if light is detected suddenly. Use this setting value only if the effect caused by external light signals is impossible.

Parameter: Sensor

- Default setting (_:14551:11) Sensor = Point sensor

Use the parameter Sensor to set which sensor type is connected to the device.

Parameter Value	Description
Point sensor	A point sensor is connected to the device.
Line sensor	A line sensor is connected to the device.
Custom	If you select this setting option, the parameter Threshold Light is visible. Siemens recommends the default setting values Point sensor or Line sensor. This allows arcs to be detected reliably regardless of diffused light.

Parameter: Threshold Light

- Default setting (_:14551:7) Threshold Light = -20.00 dB

Use the parameter Threshold Light to set the light sensitivity. If you set the Threshold Light to a smaller value, the sensitivity increases. If you set the Threshold Light to a higher value, the sensitivity decreases. If the sensors even pick up in case of a switching arc of the circuit breaker, set the Threshold Light parameter to a higher value.
Siemens recommends the default settings for point or line sensors.
Set the parameter Threshold Light manually only if you have special default settings for light sensitivity.

Parameter: Channel

- Default setting (_:14551:10) Channel = no channel is selected

Use the parameter Channel to select which sensor channel the stage uses.
If the Arc protection function has several stages, a different channel must be selected for each stage.
For parameter Channel, the selection texts are identical to the name of the arc-protection module and its channels.

7.28.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:3	General:Threshold I>	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
_:2311:4	General:Threshold 3I0>	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
Stage 1				
_:14551:1	Stage 1:Mode		• off • on • test	off
_:14551:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:14551:9	Stage 1:External trip initiation		• no • yes	no
_:14551:8	Stage 1:Operating mode		• Light only • Current and light	Current and light
_:14551:11	Stage 1:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14551:7	Stage 1:Threshold Light		-28.00 dB to 0.00 dB	-20.00 dB
_:14551:10	Stage 1:Channel		Setting options depend on configuration	

Addr.	Parameter	C	Setting Options	Default Setting
Stage 2				
_:14552:1	Stage 2:Mode		• off • on • test	off
_:14552:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:14552:9	Stage 2:External trip initiation		• no • yes	no
_:14552:8	Stage 2:Operating mode		• Light only • Current and light	Current and light
_:14552:11	Stage 2:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14552:7	Stage 2:Threshold Light		-28.00 dB to 0.00 dB	-20.00 dB
_:14552:10	Stage 2:Channel		Setting options depend on configuration	
Stage 3				
_:14553:1	Stage 3:Mode		• off • on • test	off
_:14553:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:14553:9	Stage 3:External trip initiation		• no • yes	no
_:14553:8	Stage 3:Operating mode		• Light only • Current and light	Current and light
_:14553:11	Stage 3:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14553:7	Stage 3:Threshold Light		-28.00 dB to 0.00 dB	-20.00 dB
_:14553:10	Stage 3:Channel		Setting options depend on configuration	

7.28.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:14551:81	Stage 1:>Block stage	SPS	I
_:14551:82	Stage 1:>External Arc	SPS	I
_:14551:54	Stage 1:Inactive	SPS	O
_:14551:52	Stage 1:Behavior	ENS	O
_:14551:53	Stage 1:Health	ENS	O
_:14551:58	Stage 1:Arc detected	SPS	O

No.	Information	Data Class (Type)	Type
_:14551:55	Stage 1:Pickup	ACD	O
_:14551:57	Stage 1:Operate	ACT	O
Stage 2			
_:14552:81	Stage 2:>Block stage	SPS	I
_:14552:82	Stage 2:>External Arc	SPS	I
_:14552:54	Stage 2:Inactive	SPS	O
_:14552:52	Stage 2:Behavior	ENS	O
_:14552:53	Stage 2:Health	ENS	O
_:14552:58	Stage 2:Arc detected	SPS	O
_:14552:55	Stage 2:Pickup	ACD	O
_:14552:57	Stage 2:Operate	ACT	O
Stage 3			
_:14553:81	Stage 3:>Block stage	SPS	I
_:14553:82	Stage 3:>External Arc	SPS	I
_:14553:54	Stage 3:Inactive	SPS	O
_:14553:52	Stage 3:Behavior	ENS	O
_:14553:53	Stage 3:Health	ENS	O
_:14553:58	Stage 3:Arc detected	SPS	O
_:14553:55	Stage 3:Pickup	ACD	O
_:14553:57	Stage 3:Operate	ACT	O

Informationen der Selbstüberwachung vom Lichtbogenschutz-Modul

No.	Information	Data Class (Type)	Type
Channel #			
_:307	Channel #:Sensor failure	SPS	O

7.28.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only

7.28.8.1 Description

Overview

The example describes the Arc protection function in a medium-voltage switchgear with one infeed and 2 feeders. The Arc protection function operates with the Operating mode = Light only.
The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function

The following figure shows the arrangement and the connection of the optical point sensors:

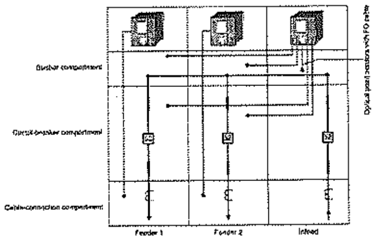


Figure 7-185 Layout and Connection of the Optical Point Sensors (Operating Mode = Light only)

For this example, the following is assumed:

- The circuit breaker of the infeed must be switched off. This ensures that the arcs in the busbar compartments of the infeed and the feeders or in the circuit-breaker compartment of the feeders are off.
  Install the optical point sensors in the busbar compartments (BB compartment) of the infeed and feeders. Install additional optical point sensors in the circuit-breaker compartment (CB compartment) of the feeders. Connect all optical point sensors to the protection device of the infeed.
- The optical point sensors in the cable connection compartment of the feeders detect arcs in this compartment. Install one optical point sensor in the cable connection compartment of the feeders and connect it to the protection device of the feeder. This allows for the selective clearing of arcs inside the cable-connection compartment.
  Due to the pressure waves that occur during the formation of an arc, partitions can deform and cause undesirable light influences in adjacent compartments. This can result in a non-selective tripping.
- If there is an arc in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must switch off.

NOTE

If the Arc protection function operates in Operating mode = Light only, the effects of external light can result in non-selective tripping.

NOTE

It must be considered that the number of arc protection modules connected to the device depends on the hardware configuration of the device.
When using modular devices, a maximum of 15 sensors can be connected. If using non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

349

7.28.8.2 Application and Setting Notes

General Notes

- Connect one optical sensor from the cable-connection compartment in feeder 1 to the protection device in feeder 1. Arcs in the cable-connection compartment are cleared selectively by the circuit breaker in feeder 1.
- Connect one optical sensor from the cable-connection compartment in feeder 2 to the protection device in feeder 2. Arcs in the cable-connection compartment are cleared selectively by the circuit breaker in feeder 2.
- Connect the optical sensors from all busbar compartments and all CB compartments of feeder 1 and 2 to the protection device in the infeed. Arcs in these compartments are detected and cleared by the device in the infeed.

Setting Information for the Protection Device in Feeder 1

The Arc protection function operates with one stage.
Set the parameters of the stage as follows:

- Parameter: `Operating mode` = `Light only`
- Parameter: `External trip initiation` = `no`
- Parameter: `Channel` = `Arc mod. 1 channel 1`

The parameters in block General are not relevant since the `Operating mode` = `Light only`.

Setting Information for the Protection Device in Feeder 2

The Arc protection function operates with one stage.
Set the parameters of the stage as follows:

- Parameter: `Operating mode` = `Light only`
- Parameter: `External trip initiation` = `no`
- Parameter: `Channel` = `Arc mod. 1 channel 1`

The parameters in block General are not relevant since the `Operating mode` = `Light only`.

Setting Information for the Protection Device in the Infeed

The Arc protection function operates with 5 stages.
Set the parameters of the stages as follows:

- Parameter: `Operating mode` = `Light only` (applies to all stages)
- Parameter: `External trip initiation` = `no` (applies to all stages)
- Parameter: `Channel` = `Arc mod. 1 channel 1` (Stage 1) → Monitoring busbar compartment in feeder 1
  Parameter: `Channel` = `Arc mod. 1 channel 2` (Stage 2) → Monitoring CB compartment in feeder 1
  Parameter: `Channel` = `Arc mod. 1 channel 3` (Stage 3) → Monitoring of busbar compartment in feeder 2
  Parameter: `Channel` = `Arc mod. 2 channel 1` (Stage 4) → Monitoring of CB compartment in feeder 2
  Parameter: `Channel` = `Arc mod. 2 channel 2` (Stage 5) → Monitoring of busbar compartment in the infeed

The parameters in block General are not relevant since the `Operating mode` = `Light only`.

7.28.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current

7.28.9.1 Description

Overview

The example describes the Arc protection function in a medium-voltage switchgear with one infeed and 2 feeders. The Arc protection function operates with the `Operating mode` = `Current and light`. In the example, all arcs are detected by the protection device in the infeed.
The following items are considered in the example:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about selected parameters in the stages of the function

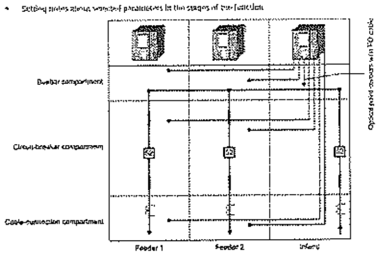


Figure 7-186 Layout and Connection of the Optical Point Sensors (Operating Mode = Current and Light)

For this example, the following is assumed:

- The current-flow criterion offers additional security to prevent unwanted tripping caused by outside light influences.
  Depending on the arc location in the cable-connection compartment of the feeder, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the feeder, the current will therefore be evaluated in the infeed.
- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders as well as the busbar compartment of the infeed. Connect the optical point sensors to the protection device in the infeed.
- The protection device in the infeed clears all arcs in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of feeder 1 and 2. Furthermore, the protection device clears arcs in the busbar compartment of the infeed.

- If the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders, or in the busbar compartment of the infeed detect an arc, the protection device in the infeed evaluates the current as well.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must trip.

> **NOTE**
> If the Arc protection function operates with the `Operating mode` = `Current and light`, the additional current-flow criterion prevents unwanted tripping caused by external light influences.

> **NOTE**
> This application example requires the connection of several optical point sensors to a single protection device. It must be considered that the number of arc-protection modules that are connected to the device depends on the hardware configuration of the device.
> When using modular devices, a maximum of 15 sensors can be connected. If you use non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

7.28.9.2 Application and Setting Notes

General Notes

- Connect the optical sensors from the busbar compartments, the CB compartments, and the cable-connection compartments of feeder 1 and 2 to the protection device in the infeed. Arcs in the busbar compartment, the CB compartment, and the cable-connection compartments of feeder 1 and 2 are detected and cleared by the device in the infeed.
- Connect the optical sensor from the busbar compartment in the infeed to the protection device in the infeed. Arcs in the busbar compartment of the infeed are cleared selectively by the circuit breaker in the infeed.

Setting Information for the Protection Device in the Infeed

The Arc protection function operates with 7 stages.
Set the parameters of the stages as follows:

- Parameter: `Operating mode` = `Current and light` (applies to all stages)
- Parameter: `External trip initiation` = `no` (applies to all stages)
- Parameter: `Channel` = `Arc mod. 1 channel 1` (Stage 1) → Monitoring busbar compartment in feeder 1
  Parameter: `Channel` = `Arc mod. 1 channel 2` (Stage 2) → Monitoring CB compartment in feeder 1
  Parameter: `Channel` = `Arc mod. 1 channel 3` (Stage 3) → Monitoring cable-connection compartment in feeder 1
  Parameter: `Channel` = `Arc mod. 2 channel 1` (Stage 4) → Monitoring busbar compartment in feeder 2
  Parameter: `Channel` = `Arc mod. 2 channel 2` (Stage 5) → Monitoring CB compartment in feeder 2
  Parameter: `Channel` = `Arc mod. 2 channel 3` (Stage 6) → Monitoring cable-connection compartment in feeder 2
  Parameter: `Channel` = `Arc mod. 3 channel 1` (Stage 7) → Monitoring busbar compartment of the infeed

Information about the settings of parameters `Threshold I>` and `Threshold 3I0>` can be found in Chapter 7.28.4 Application and Setting Notes – General Settings.

7.28.10 Application Example for Arc Protection with Point Sensors via External Trip Initiation

7.28.10.1 Description

Overview

The example describes the Arc protection function in a medium-voltage switchgear with one infeed and 2 feeders. The stages of the Arc protection function are triggered by `External trip initiation`.
The following items are considered in the example:

- Positioning the optical sensors in the switchgear
- Connecting the optical sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about selected parameters in the stages of the function

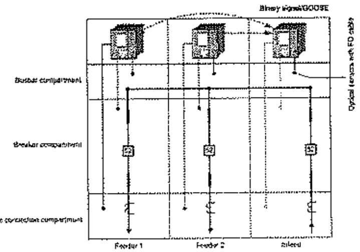


Figure 7-187 Arc Protection with External Trip Initiation – Variant 1 (without Feedback to Feeder Protection Devices)

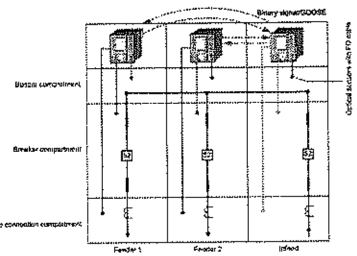


Figure 7-188 Arc Protection with External Trip Initiation – Variant 2 (with Feedback to Feeder Protection Devices)

For this example, the following is assumed:

- Install the optical sensors in the busbar compartment, the CB compartment, and the cable-connection compartment of the feeder and the infeed. Connect the optical sensors to the respective protection device in the feeder and infeed.
- If the optical sensors detect an arc in the busbar compartment, the CB compartment, or the cable-connection compartment of the feeders, the indication `Arc detected` is sent via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device in the infeed. Then, the protection device in the infeed evaluates the current as well. If the measured current exceeds the thresholds `Threshold I>` and/or `Threshold 3I0>`, the protection device in the infeed clears the malfunction.
  You can find detailed information in chapter 7.28.10.2 Application and Setting Notes for Variant 1 (without Feedback to Feeder Protection Devices).
- Alternatively, arcs in the cable-connection compartment of the feeders can be cleared selectively by the protection device of the affected feeder. To do this, the pickup indication from the infeed unit must be sent back to the appropriate protection device in the feeder.
  You can find detailed information in chapter 7.28.10.3 Application and Setting Notes for Variant 2 (with Feedback to Feeder Protection Devices).
- If an arc occurs in the CB compartment and in the cable-connection compartment of the infeed, the superordinate protection device trips.

> **NOTE**
> If the Arc protection function operates via the `External trip initiation`, only 3 optical sensors are required per feeder protection device in order to detect arcs (only one arc-protection module).
> The signals from the feeder protection devices are sent via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device of the infeed and processed there.
> The number of GOOSE messages is not limited. Therefore, the number of feeders is not limited, and the protection of complex systems is possible.
> Siemens recommends using the Arc protection function with external trip initiation.

7.28.10.2 Application and Setting Notes for Variant 1 (without Feedback to Feeder Protection Devices)

General Notes:

- Install the optical sensors in the busbar compartment, the CB compartment, and the cable-connection compartment of the feeders and the infeed to the respective protection devices.
- Arcs in the busbar compartment, the CB compartment, and the cable-connection compartment of the feeders must be switched off by the protection device in the infeed. To do this, the protection devices in the feeder device must send the indication `Arc detected` to the infeed device. Use the binary inputs/outputs, a protection interface, or IEC 61850 GOOSE.
- The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds `Threshold I>` and/or `Threshold 3I0>`, the protection device in the infeed clears the malfunction.
  Connect the signals using 6 stages with the external trip initiation or a CFC chart.

Setting Information for the Protection Device in Feeder 1

The Arc protection function operates with 3 stages.
Set the parameters of the stages as follows:

- Parameter: `Operating mode` = `Light only` (applies to all stages)
- Parameter: `External trip initiation` = `no` (applies to all stages)
- Parameter: `Operate & flt.rec. blocked` = `yes` (applies to all stages)
- Parameter: `Channel` = `Arc mod. 1 channel 1` (Stage 1) → Monitoring busbar compartment in feeder 1
  Parameter: `Channel` = `Arc mod. 1 channel 2` (Stage 2) → Monitoring CB compartment in feeder 1
  Parameter: `Channel` = `Arc mod. 1 channel 3` (Stage 3) → Monitoring cable-connection compartment in feeder 1

Setting Information for the Protection Device in Feeder 2

The Arc protection function operates with 3 stages.
Set the parameters of the stages as follows:

- Parameter: `Operating mode` = `Light only` (applies to all stages)
- Parameter: `External trip initiation` = `no` (applies to all stages)
- Parameter: `Operate & flt.rec. blocked` = `yes` (applies to all stages)
- Parameter: `Channel` = `Arc mod. 1 channel 1` (Stage 1) → Monitoring busbar compartment in feeder 2
  Parameter: `Channel` = `Arc mod. 1 channel 2` (Stage 2) → Monitoring CB compartment in feeder 2
  Parameter: `Channel` = `Arc mod. 1 channel 3` (Stage 3) → Monitoring cable-connection compartment in feeder 2

350

Setting Information for the Protection Device in the Infeed

The Arc protection function operates with 9 stages.

Stage 1 (busbar-compartment monitoring):

- Parameter: Operate & flt.rec. blocked = no
  If an arc is detected in the busbar compartment and the thresholds Threshold I> and/or Threshold 3I0> are exceeded, an operate indication is generated immediately.
- Parameter: Channel = Arc mod. 1 channel 1
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = no

Stage 2 (CB compartment monitoring):

- Parameter: Operate & flt.rec. blocked = yes
  If an arc is detected in the CB compartment of the infeed (light-gray sensors in Figure 7-287), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
- Parameter: Channel = Arc mod. 1 channel 2
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = no

Stage 3 (cable-connection compartment monitoring):

- Parameter: Operate & flt.rec. blocked = yes
  If an arc is detected in the cable-connection compartment of the infeed (light-gray sensors in Figure 7-287), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
  Depending on the arc location in the cable-connection compartment of the infeed, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the infeed, the current must be evaluated by the superordinate protection device.
- Parameter: Channel = Arc mod. 1 channel 3
- Parameter: Operating mode = Light only
- Parameter: External trip initiation = no

Stage 4 to 9 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = no
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = yes
  If an arc is detected in the busbar compartment, the CB compartment, or the cable-connection compartment of the feeder, the feeder device sends the indication *Arc detected* to the infeed device. An external trip initiation via these stages is effective only if the indication *Arc detected* is connected with the signal *>External Arc* in the infeed device.
  The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed clears the arc.

7.28.10.3 Application and Setting Notes for Variant 2 (with Feedback to Feeder Protection Devices)

General Notes

- Connect the optical sensors in the busbar compartment, the CB compartment, and the cable-connection compartment of the feeder 1 and 2 and the infeed to the respective protection devices.
- Arcs in the busbar compartment and in the CB compartment of the feeders must be cleared by the protection device in the infeed. To do this, the protection devices in the feeder must send the indication *Arc detected* to the infeed device. Use the binary inputs/outputs, a protection interface, or IEC 61850 GOOSE.

- Arcs in the cable-connection compartment of the feeder are cleared selectively. Here, the message *Arc detected* is sent as well via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device in the infeed.
  The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values Threshold I> and/or Threshold 3I0>, the protection device in the infeed sends the pickup indication of the stage back to the protection device in the affected feeder. The protection device in the affected feeder clears the arc selectively.
  Due to the pressure wave that occurs during an arc, partitions may deform and cause undesirable light influences in adjacent compartments. This may result in a non-selective trip.

> **NOTE**
>
> The External trip initiation function must be instantiated in the protection devices of the feeders.

Setting Information for the Protection Device in Feeder 1

The Arc protection function operates with 4 stages.

Stage 1 to 3:

- Parameter: Operating mode = Light only
- Parameter: External trip initiation = no
- Parameter: Operate & flt.rec. blocked = yes
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Monitoring busbar compartment in feeder 1
  Parameter: Channel = Arc mod. 1 channel 2 (Stage 2) → Monitoring CB compartment in feeder 1
  Parameter: Channel = Arc mod. 1 channel 3 (Stage 3) → Monitoring cable-connection compartment in feeder 1

Stage 4 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = no
- Parameter: Operating mode = Light only
- Parameter: External trip initiation = yes
  If an arc is detected in the cable-connection compartment of the feeder, the indication *Arc detected* is sent to the protection device in the infeed.
  The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed picks up. The pickup indication from the protection device in the infeed is injected via this stage into the feeder protection device. This makes a selective tripping in the feeder possible.

Setting Information for the Protection Device in Feeder 2

The Arc protection function operates with 4 stages.

Stage 1 to 3:

- Parameter: Operating mode = Light only
- Parameter: External trip initiation = no
- Parameter: Operate & flt.rec. blocked = yes
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Monitoring busbar compartment in feeder 2
  Parameter: Channel = Arc mod. 1 channel 2 (Stage 2) → Monitoring CB compartment in feeder 2
  Parameter: Channel = Arc mod. 1 channel 3 (Stage 3) → Monitoring cable-connection compartment in feeder 2

Stage 4 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = no
- Parameter: Operating mode = Light only
- Parameter: External trip initiation = yes
  If an arc is detected in the cable-connection compartment of the feeder, the indication *Arc detected* is sent to the protection device in the infeed.
  The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed picks up. The pickup indication from the protection device in the infeed is injected via this stage into the feeder protection device. This makes a selective tripping in the feeder possible.

Setting Information for the Protection Device in the Infeed

If arcs in the cable connection compartments of the feeder shall be switched off selectively by the protection device in the feeder, the following setting notes for the protection device in the infeed apply.

The Arc protection function operates with 9 stages.

Stage 1 (busbar-compartment monitoring):

- Parameter: Operate & flt.rec. blocked = no
  If an arc is detected in the busbar compartment of the infeed, an operate indication is generated immediately.
- Parameter: Channel = Arc mod. 1 channel 1
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = no

Stage 2 (CB compartment monitoring):

- Parameter: Operate & flt.rec. blocked = yes
  If an arc is detected in the CB compartment of the infeed (light-gray sensors in Figure 7-287), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
- Parameter: Channel = Arc mod. 1 channel 2
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = no

Stage 3 (cable-connection compartment monitoring):

- Parameter: Operate & flt.rec. blocked = yes
  If an arc is detected in the cable connection compartment of the infeed (light-gray sensors in Figure 7-287), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
  Depending on the arc location in the cable-connection compartment of the infeed, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the infeed, the current must be evaluated by the superordinate protection device.
- Parameter: Channel = Arc mod. 1 channel 3
- Parameter: Operating mode = Light only
- Parameter: External trip initiation = no

Stage 4 to 7 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = no
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = yes

If an arc is detected in the busbar compartment or the CB compartment of the feeders, the feeder device sends the indication *Arc detected* to the infeed device. An external trip initiation via these stages is effective only if the indication *Arc detected* is connected with the signal *>External Arc* in the infeed device.
The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed clears the arc.

Stage 8 and 9 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = yes
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = yes

If an arc is detected in the cable-connection compartment of the feeder, the feeder device sends the indication *Arc detected* to the infeed device. An external trip initiation via these stages is effective only if the indication *Arc detected* is connected with the signal *>External Arc* in the infeed device.
The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed picks up. The pickup indication *Arc detected* will be sent back to the feeder protection device. This makes a selective tripping in the feeder possible.

8 Supervision Functions

8.1 Overview

SIPROTEC 5 devices are equipped with an extensive and integrated supervision concept. Continuous supervision:

- Ensures the availability of the technology used
- Avoids overfunction and underfunction of the device
- Protects persons and primary technical devices
- Offers effective assistance during commissioning and testing

The following areas are monitored:

- Supervision the resource consumption of the application
- Supervision of the secondary system
- Supervision of device hardware
- Supervision of device firmware
- Supervision of hardware configuration
- Supervision of communication connections

When the supervision functions pick up, this will be displayed and also indicated. Error responses are defined for the device. The error responses are grouped in defect severities.
The supervision functions work selectively. When the supervision functions pick up – as far as possible – only the affected parts of the hardware and firmware are blocked. If this is not possible, the device goes out of operation into a secure state (fallback mode). In addition to safety, this warrants a high degree of availability.

351

8.2 Resource-Consumption Supervision

8.2.1 Load Model

SIPROTEC 5 devices are freely configurable. A load model is integrated in DIGSI 5. The load model prevents you from overloading the device with an excessively large application.

The load model shows the device utilization and the response times for device functions. If it determines that an application created is likely to overload the device, DIGSI 5 prevents the application from being loaded into the device.

In this rare case, you must then reduce the application in order to be able to load it into the device.

The load model can be found in the DIGSI 5 project tree under Name of the device → Device information. In the operating range, select the **Resource consumption** setting sheet. The following figure shows an example of the view of the load model in DIGSI 5:

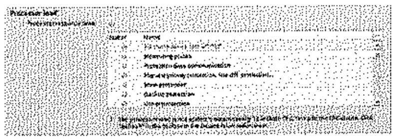


Figure 8-1 Visualization of the Load Model in DIGSI

A green total display for the processor response time indicates that the device is not overloaded by the present application. On the other hand, if you see a red exclamation mark, the planned application is overloading the device.

The list below the total display shows the individual functional areas. These areas combine functions with the same real-time requirements in groups. A green display in front of an area (see Figure 8-1) indicates that the response times of the functions grouped in this area can be maintained. A red exclamation point indicates that functions may have longer response times than are specified in the Technical data for the device. In such a case, loading of the application into the device is blocked.

The following table provides an overview of the functional areas and the most important influencing quantities on device utilization:

Functional Area	Brief Description	Change in Load
CFC event-triggered, fast	CFC charts that must be processed especially fast (for example, to lower interlock flags between protection functions)	Adding or removing CFC charts in the fast event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the fast event-triggered process area
Measuring points	Provision of measured values for protection, control, and measurement functions	Adding or removing • Measuring points (in the Measuring-points routing editor) • Function groups that provide measured-value processing for invariable functions (for example, Circuit-breaker function group)
• FG connections • Fast GOOSE	• Interaction between individual function groups, for example, between the Line function group and the Circuit-breaker function group • Fast GOOSE communication	Adding or removing • Protection functions and their stages • Circuit-breaker function groups • Fast GOOSE connections
Main protection	Protection functions with high requirements for fast operate times	Adding or removing functions and tripping stages of the instantaneous high-current tripping
Backup protection	Protection functions with average requirements for fast operate times	Adding or removing • Functions and stages of overcurrent protection • Synchronization function
Other protection	Protection functions with low requirements for fast operate times	Adding or removing • Overload protection functions • Functions and stages of voltage protection • All functions not listed previously
CFC event-triggered, standard GOOSE	CFC charts with a maximum processing time of 40 ms	Adding or removing CFC charts in the event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the event-triggered process area
• Control • Other continuous function chart • Operational measured values	• Control and interlocking • CFC charts in the area of control, measured value preprocessing, and event-controlled • Operational measured values	Adding or removing • Function blocks for control and interlocking • CFC charts in the control area • Switching devices (except circuit breakers), for example, disconnector function groups • Operational measured values • CFC charts in the measured values area

If the load model displays a warning, bear in mind the following general instructions:

The areas named in the table are listed in descending order of real-time requirements. If a warning appears to the effect that the guaranteed response times may be exceeded in an area, you may be able to return to the permitted area by taking the following measures:

- Reduce the functional scope in the marked area (red exclamation mark)
- Reduce the functional scope in another area with higher real-time requirements

When you have reduced the application, check the display in resource consumption. If a function or stage has been switched off, it will continue to represent a load for the area. If you do not need the function or stage, delete it rather than switching it off.

Use the general Circuit-breaker function group only in the following cases:

- Interaction with a protection-function group is essential.
  That is, operate indications of protection functions cause the circuit breaker assigned in the Circuit-breaker function group to be switched off.
- You want to use functions such as the automatic reclosing function or circuit-breaker failure protection in the Circuit-breaker function group.

If a circuit breaker is only to be modeled for control purposes, use the Circuit breaker [state only] function group.

8.2.2 Function Points

When you order a SIPROTEC 5 device, you are also ordering a function-points account for use of additional functions.

The following figure illustrates consumption of function points in the current application with respect to the existing function-points account.

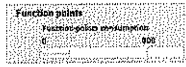


Figure 8-2 Resource Overview: Function-Points Consumption

The remaining white bar shows the function points that have not yet been used up by your configuration. The number of function points available in a device depends on the device purchase order (position 20 of the product code). You can also order function points subsequently, and so increase the function-points account for the device.

> **NOTE**
>
> Find out the function-points requirement for the desired application before ordering the device. For this, you can use the device configurator.

8.2.3 CFC Resources

Task Levels of the CFC Function

A CFC chart, and thus the configured CFC function, runs in the SIPROTEC 5 device on exactly one of the 4 task levels. The individual task levels differ, on the one hand, in the priority of processing tasks and, on the other, in the cyclic or event-triggered processing of the CFC charts.

You can select between the following task levels:

Task Level	Description
Fast Event-Triggered	Use the Fast Event-Triggered task level for time-critical tasks, for example, if a signal should block a protection function within 2 ms to 3 ms. Functions on this task level are processed in an event-triggered way with the highest priority. Each change to a logical input signal is immediately processed. Processing can interrupt the execution of protection functions and functions on the Event-Triggered task level.
Event-Triggered	Use the Event-Triggered task level preferably for logic functions that need not be executed with highest priority. Each change to a logical input signal is immediately processed. Protection functions or functions on the Fast Event-Triggered task level can disrupt processing. Functions on the Event-Triggered task level are typically processed within a maximum of 5 ms in all devices. For busbar protection or line protection, the functions on the Event-Triggered task level are processed within a maximum of 10 ms.
Measurement	Use the Measurement task level for processing measured values. Functions on this task level are processed cyclically every 500 ms.
Interlocking	Use the Interlocking task level preferably for logic functions that should be executed with lower priority than functions in the Event-Triggered task level. If the available ticks of the Event-Triggered task level shown in the following figure are sufficient for the required CFC functionality, you do not need to use the Interlocking task level.

All CFC function blocks can be assigned to all the task levels. There are no device-specific function blocks. If enough ticks are available, all CFC charts can be created in the same task level. A tick is the measure of the performance requirement of CFC blocks.

The number of available ticks for each task is calculated depending on the created device configuration. This calculation is based on the previously described load model. In this process, it is recommended to create all selected functions and objects first followed by configuration of the CFC charts so that available information about the remaining system capacitance for CFC charts is available. Significantly exceeding the typical response time is prevented by the load model by limiting the number of CFC function blocks in the corresponding task level via the number of ticks available.

The typical response times for CFC tasks are listed in the Technical Data.

The following figure shows an example of the CFC chart capacitances in DIGSI calculated by the load model. The ticks available for each task are shown here. The green bars represent the ticks used in the task levels. You reach this dialog with the following call: Device → Device information → Resource consumption.

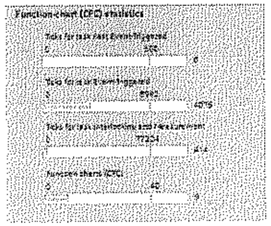


Figure 8-3 CFC Statistics

> **NOTE**
>
> The fast-event-triggered CFC charts have the highest priority and are processed before all other tasks. At this level, a considerable smaller number of ticks are available than at all other tasks. It is recommended to configure only very-high-priority logic functions at this task and to configure the other logic functions in any other level.

> **NOTE**
>
> Empty CFC charts also consume system resources. Empty charts that are not required any more should be deleted.

8.3 Supervision of the Secondary System

8.3.1 Overview

The secondary circuits establish a connection to the power system from the point of view of the device. The measuring-input circuits (currents, voltages) as well as the command circuits to the circuit breakers are monitored for the correct function of the device. The connection to the station battery is ensured with the supervision of the external auxiliary voltage. The secondary system has the following supervision systems:

Measuring circuits (voltage):

- Measuring-Voltage Failure
- Voltage Transformer Circuit Breaker
- Voltage balance
- Voltage sum
- Voltage rotating field

Measuring circuits (current):

- Broken conductor of the current circuits
- Current balance
- Current sum
- Current rotating field

Trip circuits

External auxiliary voltage

When these supervisions pick up, corresponding warning indications are output. Some supervisions lead directly to the blocking of affected protection functions or to the marking of measuring points that have become invalid, so that affected protection functions can go into a secure state.

A detailed description of the supervision mechanisms and their error responses can be found in the Function Description and as overall overview at the end of chapter 8.

8.3.2 Measuring-Voltage Failure

8.3.2.1 Overview of Functions

The **Measuring-voltage failure detection** function monitors the voltage transformer secondary circuits:

- Non-connected transformers
- Pickup of the voltage transformer circuit breaker (in the event of short circuits in the secondary circuit)
- Broken conductor in one or more measuring loops

All these events cause a voltage of 0 in the voltage transformer secondary circuits which can lead to failures of the protection functions.

For the following protection functions, the response (Block/not block) to a measuring-voltage failure can be set within the function:

- Overvoltage protection with negative-sequence voltage
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with positive-sequence voltage

8.3.2.2 Structure of the Function

The function is part of protection function groups which are connected with a 3-phase voltage and current measurement point.

Protection function group

Function Measuring-voltage failure detection

Figure 8-4 Structure/Embedding of the Function

The function is broken down into 3 subfunctions (see Figure 8-5):

- Supervision for unbalanced measuring-voltage failure
- Supervision for 3-phase measuring-voltage failure
- Supervision for switching onto a 3-phase measuring-voltage failure

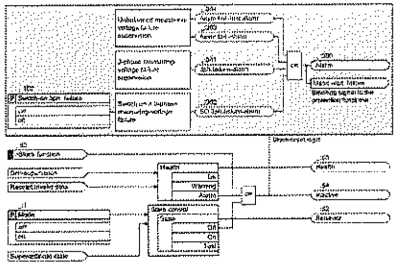


Figure 8-5 Breakdown of the Measuring-Voltage Failure Detection Function

Each subfunction creates its own monitoring indication. The function summarizes these indications via the group indication Alarm.

The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

8.3.2.3 Unbalanced Measuring-Voltage Failure

Logic

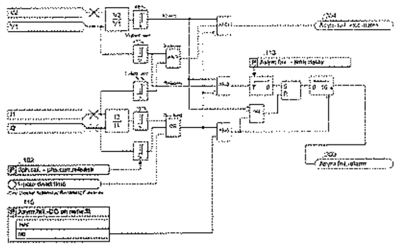


Figure 8-6 Logic Diagram Unbalanced Measuring-Voltage Failure Detection

The criterion for detection of an unbalanced measuring-voltage failure is the voltage unbalance. This unbalance is determined based on the ratio between negative and positive-sequence voltage. If the threshold value is violated and the monitoring is released and not blocked, the monitoring picks up (see Figure 8-6). The indication Asym. fail. - inst. alarm is output.

The monitoring is released as soon as a certain minimum voltage is exceeded. This prevents a spurious response in the presence of low voltage amplitudes or a measured of 0 (for example, circuit breaker open). Instantaneous monitoring also requires the presence of a minimum current. This prevents a spurious instantaneous pick up of the monitoring in the presence of a weak infeed (current < 10 % of rated current) combined with a power-system incident.

If the voltage unbalance is blocked by unbalanced faults in the primary system, the supervision is blocked. The device detects an unbalanced fault based on the ratio between negative sequence and positive-sequence current. In the event of 1-pole automatic reclosing, the supervision is blocked.

Delay/Seal-In

In the presence of a weak infeed (current < 10 % of rated current), certain protection functions require more time for detection of a system incident. For this purpose, the monitoring can be delayed using the Asym. fail. - time delay parameter.

If a system incident is detected during the time delay, the supervision drops off. This is because the function assumes that the unbalance - and consequently the pickup of the supervision - is due to the system incident.

After the time delay has elapsed, it definitely assumes a measuring-voltage failure. The monitoring seals in and the Asym. fail. - alarm indication is output. The dropout does not happen until the voltage unbalance has disappeared after a seal-in time of 10 s. In the presence of 3-pole close-in faults outside the protection zone, this seal-in time prevents the monitoring from dropping off too quickly and thus releasing the protection functions.

The sealing-in function can be deactivated using the Asym. fail. -DO on netw. flt. parameter. As soon as a system incident is detected, the monitoring drops off instantaneously.

8.3.2.4 3-Phase Measuring-Voltage Failure

Logic

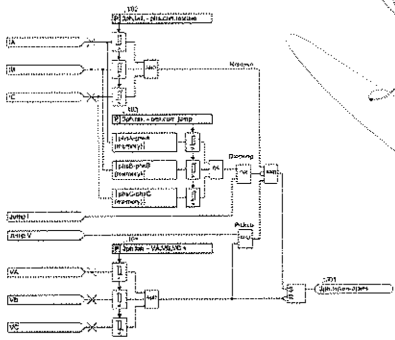


Figure 8-7 Logic Diagram 3-Phase Measuring-Voltage Failure

Balanced Fault – VA, VB, VC <

A 3-phase measuring-voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages drop below the threshold value 3ph. fail. - VA,VB,VC <
- A jump of the voltage (Signal Jump V)

If these criteria are fulfilled and the monitoring is released and not blocked, the 3ph. failure-alarm indication is output. When the voltage returns (even at 1 phase), the monitoring drops out.

Release by Phase Current

When all phase currents exceed the threshold value 3ph. fail. - phs.curr.release the monitoring is released.

Blocking in the Case of a System Incident

In the case of a 3-phase system incident, supervision must be blocked. The device detects a 3-phase incident with a jump in the current. This change is detected via the internal signal Jump I or when the change in current of a phase current exceeds the threshold value 3ph. fail. - phs.curr. jump. The change in

current of phase currents is formed from the difference between the present current phasor and the current phasor of the previous period. This allows to take into account a jump of the current phase.

8.3.2.5 Switching onto a 3-Phase Measuring-Voltage Failure, Low Load

Logic

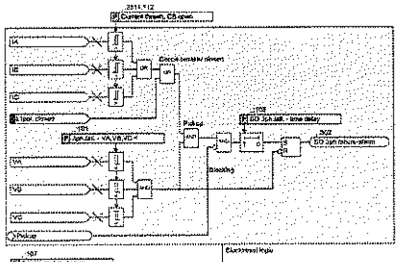


Figure 8-8 Logic Diagram Switching to 3-Phase Measuring-Voltage Failure

Switching onto a 3-phase measuring-voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages have dropped below the threshold value 3ph. fail. - VA,VB,VC <.
- The circuit breaker is detected to be in closed position. The detection takes place either via the phase currents or via the 1-pole closed signal, which is generated via the circuit-breaker auxiliary contacts. You can find more detailed information in chapter 5.2 Circuit-Breaker Condition for the Protected Object.

A voltage jump, such as in a 3-phase measuring-voltage failure with closed circuit breaker (see chapter 8.3.2.4 3-Phase Measuring-Voltage Failure) – does not occur in the case of switching to a 3-phase measuring-voltage failure. If the monitoring is not blocked, the time delay SO 3ph. fail. - time delay is started. After the time has elapsed, the indication SO 3ph. failure-alarm is displayed. A dropout of the monitoring is only possible by a recovery of the voltage.

The subfunction is blocked as soon as a pickup of a protection function is detected within a protection function group and the time delay of the supervision has not yet elapsed.

This subfunction also covers the situation of a low load with 3-phase measuring-voltage failure and closed circuit breaker, because the circuit-breaker condition is also determined from the circuit-breaker auxiliary

contacts. The subfunction for detecting a 3-phase measuring-voltage failure (see chapter 8.3.2.4 3-Phase Measuring-Voltage Failure) is not released in this situation, for example, because the current flow is too low. This subfunction can be switched on or off separately using the Switch-on 3ph. failure parameter.

8.3.2.6 Application and Setting Notes

Parameter: Asym.fail. - time delay

- Recommended setting value (_:113) Asym fail. - time delay = 10.00 s

The Asym. fail. - time delay parameter allows you to set the time during which a system incident detected after the occurrence of the unbalance resets the monitoring. This setting is important in the case of weak infeed (current < 10 % of rated current) in order to give certain protection functions (such as distance protection) more time for detecting system incidents. As long as the time delay runs, it is assumed that the unbalance is due to a system incident.

As soon as the time has elapsed, the supervision assumes a measuring-voltage failure and seals in.

Siemens recommends using the default setting.

If you want the seal-in function to operate sooner or at once, you can reduce the time.

Parameter: Asym.fail.-DO on netw.flt.

- Recommended setting value (_:115) Asym.fail.-DO on netw.flt. = no

Parameter Value	Description
no	After elapse of the time delay the supervision function seals in. Even if the system incident criterion is fulfilled, the protection functions concerned will remain blocked. This avoids an unselective tripping of the protection functions due to an absence of the measuring voltage in the case of an unbalanced system incident. This is the default setting.
yes	The seal-in function is switched off. The supervision drops out immediately when a system incident is detected. With this setting, the unbalanced measuring-voltage failure is only reported, and in the event of a double failure (measuring-voltage failure and system incident in parallel), unselective tripping is preferred.

Parameter: 3ph.fail. - VA,VB,VC <

- Recommended setting value (_:101) 3ph.fail. - VA,VB,VC < = 5 V

The 3ph.fail. - VA,VB,VC < parameter allows you to set the pickup value of the monitoring.

Siemens recommends using the default setting.

If you expect major disturbances acting upon the voltage inputs, you can increase this value. Increasing the values makes the supervision more sensitive to 3-phase system incidents.

Parameter: 3ph fail. - phs curr.release

- Recommended setting value (_:102) 3ph.fail. - phs curr.release = 0.1 A for I_{rated} = 1 A or 0.5 A for I_{rated} = 5 A

The 3ph.fail. - phs.curr.release parameter is used to define the phase current threshold above which the monitoring is released.

Siemens recommends using the default setting.

Parameter: 3ph.fail. - phs.curr. jump

- Recommended setting value (_:103) 3ph.fail. - phs.curr. jump = 0.1 A for I_{rated} = 1 A or 0.5 A for I_{rated} = 5 A

The 3ph. fail. - phs. curr. jump parameter is used to set the differential current between the present current phasor and the stored phasor (from the previous period). If the value is exceeded, the function detects a system incident and blocks the monitoring.

Siemens recommends using the default setting.

Parameter: SO 3ph.fail. - time delay

- Recommended setting value (_:106) SO 3ph.fail. - time delay = 3.00 s

The SO 3ph.fail. - time delay parameter allows you to set the delay of the monitoring.

Siemens recommends using the default setting.

> **NOTE**
>
> Adapt the SO 3ph.fail. - time delay parameter to the inherent time of protection functions which are intended to block the monitoring function.
>
> Note that with parameter values the blocking of the monitoring function via a protection stimulation will not be possible any more.

Parameter: Switch-on 3ph. failure

- Recommended setting value (_:107) Switch-on 3ph. failure = on

Parameter Value	Description
on	The subfunction Switching to a 3-phase measuring-voltage failure is active. In the case of low loads, the subfunction for detection of a 3-phase measuring-voltage failure is not released, for example, because the current flow is too low. In this situation, the subfunction Switching to a 3-phase measuring-voltage failure can perform the monitoring task. Siemens recommends to switch this subfunction on.
off	With the setting off the subfunction Switching to a 3-phase measuring-voltage failure is not active.

8.3.2.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Meas.v.fail.det				
_:1	Meas.v.fail.det?:Mode		• off • on • test	on
_:115	Meas.v.fail.det:Asym.fail.-DO on netw.flt.		• no • yes	no
_:113	Meas.v.fail.det:Asym.fail. - time delay		0.00 s to 30.00 s	10.00 s
_:102	Meas.v.fail.det:3ph.fail. - phs.curr.release	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

353

Addr.	Parameter	C	Setting Options	Default Setting
_:103	Meas.v.fail.det:3ph.fail.-phs.curr. bump	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
_:101	Meas.v.fail.det:3ph.fail.-VA,VB,VC <		0.300 V to 340.000 V	5.000 V
_:107	Meas.v.fail.det:Blk.det.-on 3ph. failure		• off • on	on
_:106	Meas.v.fail.det:SO 3ph.fail. - time delay		0.01 s to 30.00 s	3.00 s

8.3.2.8 Information List

No.	Information	Data Class (Type)	Type
Meas.v.fail.det			
_:82	Meas.v.fail.det:>Block function	SPS	I
_:54	Meas.v.fail.det:Inactive	SPS	O
_:52	Meas.v.fail.det:Behavior	ENS	O
_:53	Meas.v.fail.det:Health	ENS	O
_:300	Meas.v.fail.det:Alarm	SPS	O
_:301	Meas.v.fail.det:Asym.fail.-inst.alarm	SPS	O
_:303	Meas.v.fail.det:Asym. fail.-alarm	SPS	O
_:201	Meas.v.fail.det:3ph.failure-alarm	SPS	O
_:302	Meas.v.fail.det:SO 3ph.failure-alarm	SPS	O

8.3.3 Signaling-Voltage Supervision

8.3.3.1 Overview of Functions

Signaling-voltage supervision is used to evaluate the validity of binary signals connected to the SIPROTEC device via binary inputs. For this purpose, one binary input is used to monitor the signaling voltage. If the signaling voltage fails, the associated binary signals are marked as invalid and a Signaling-voltage malfunction indication is issued.

Several signaling-voltage supervision groups can be created in one SIPROTEC device. Each of these groups monitors an adjustable area with binary inputs.

8.3.3.2 Structure of the Function

The Signaling-voltage supervision function group contains, besides the general functionality, one preinstantiated Supervision group stage. The Supervision group stage can be instantiated in DIGSI 5 multiple times.

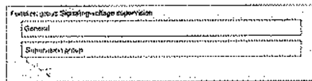
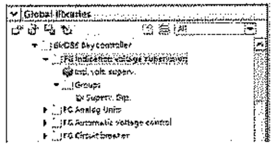


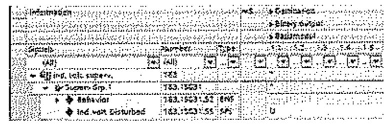
Figure 8-? Structure/Embedding of the Function Group

8.3.3.3 Function Description

You can instantiate the Signaling-voltage supervision function group in DIGSI from the global library. It contains 1 pre-instantiated Supervision group function block (see the following figure). You can instantiate a maximum of 25 supervision groups.

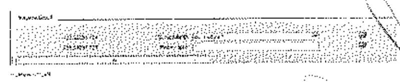


Following the instantiation of the function group in the DIGSI project tree, it appears in the information routing of DIGSI (see the following figure). The status indications of the supervision groups can be routed here, for example, to existing binary outputs and/or logs.



Set the binary input used for signaling-voltage supervision within one input/output module using the setting option (see the following figure). This binary input monitors the presence of the signaling voltage. If the signaling voltage fails, this sets the quality attribute for all other binary inputs of the parameterized input/output module to invalid. The signal status of each of these binary inputs is frozen with its last valid value prior to the occurrence of the fault. The quality attribute of the binary inputs for other input/output modules are not taken into consideration by this.

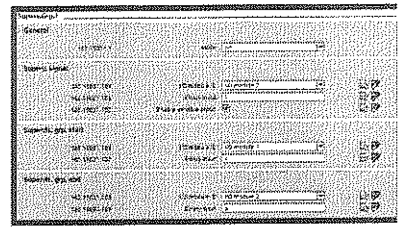
If the signaling voltage again exceeds the binary threshold, the quality attribute of the binary inputs is reset to valid.



NOTE

Each status change of the monitored binary inputs is delayed by 1 ms.

You can also combine binary inputs across modules in one Supervision group function block, and define any binary input within this group for the supervision of the signaling voltage. For this purpose, place a check mark at the parameter (_:102) Enable variable group when configuring the supervision group. This extends the parameter menu by the sections Start supervision group and End supervision group (see the following figure).



There, for example, you are able to combine 1 to n different binary inputs into one supervision group. When doing so, the binary inputs on the input/output modules assignable to a supervision group must be related logically. With 3 input/output modules, for example, this allows only consecutive binary inputs to be grouped on the modules 1+2 or 2+3, but no binary inputs on modules 1+3. The binary inputs used for supervision can be located on any input/output module within the group defined in this manner.

If you have to monitor several binary inputs that, for example, work with different signaling voltages from different sources, then you can also instantiate and configure several Supervision group function blocks within the Signaling-voltage supervision function group accordingly.

Within different supervision groups, only those consecutive binary inputs that are not already assigned to another supervision group can be grouped. The overlapping of binary inputs in different supervision groups is not permitted.

Example: There are 4 input/output modules. Binary inputs of input/output module 1+2 are already combined in supervision group 1. The 2 last binary inputs on module 2 are not included in the grouping. Thus, only these 2 binary inputs not used in the supervision group 1 of the input/output module 2 as well as, where applicable, further consecutive binary inputs of input/output modules 3+4 can be combined in supervision group 2.

Error parameters are displayed to you by inconsistency indications in DIGSI.

8.3.3.4 Application and Setting Notes

Parameter (General): Mode

- Default setting (_:1) Mode = on

With the Mode parameter, you specify whether you want to activate, deactivate, or test the supervision of the signaling voltage for the appropriate group. If you put the group into test mode, the sfg.. volt. disturbed indication is given a test flag. If the supervision input drops out in test mode, the assigned inputs retain their status without their quality attribute being set to invalid.

Parameter (Supervision Signal): I/O module ID

- Default setting (_:104) I/O module ID = I/O module 1

Using the I/O module ID parameter, you specify the I/O module for which you want to activate signaling-voltage supervision. Counting of the I/O modules starts in increasing order with the binary inputs of the base module. The binary inputs of the PS201 power supply module permanently installed in the base module count as the 2nd I/O module followed by additional I/O modules (3 to n) in the expansion boards of the device.

Parameter (Supervision Signal): Binary input

- Default setting (_:105) Binary input = 1

Using the Binary input parameter, you specify the binary input responsible for the supervision of the signaling voltage for the parameterized I/O module. The quality attribute of all other binary inputs for this module are set to valid or invalid depending on the presence of the signaling voltage at the parameterized binary input.

Parameter (Supervision Signal): Enable variable group

- Default setting (_:102) Enable variable group = unfalse

You can activate the parameter Enable variable group by placing the check mark. If you have not set the check mark (default setting), only three 2 parameters are available for the configuration of the supervision signal. If you have set the check mark, the parameter menu is extended by the areas Start supervision group and End supervision group. You can then use that to carry out the grouping of binary inputs for supervision groups explained in the function description.

Parameter (Start Supervision Group): I/O module ID

- Default setting (_:106) I/O module ID = I/O module 1

Parameter I/O module ID is used to define the first I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the lowest counter number that you can use for setting up a grouping.

Parameter (Start Supervision Group): Binary input

- Default setting (_:107) Binary input = 1

Parameter Binary input is used to define the lowest binary input for the first I/O module (see (_:106) I/O module ID) that you want to assign to a supervision group.

Parameter (End Supervision Group): I/O module ID

- Default setting (_:108) I/O module ID = I/O module 1

Parameter I/O module ID is used to define the last I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the highest counter number that you can use for carrying out a grouping.

Parameter (End Supervision Group): Binary input

- Default setting (_:109) Binary input = 1

Parameter Binary input is used to define the highest binary input for the last I/O module (see (_:108) I/O module ID) that you want to assign to a supervision group.

8.3.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Superv.Grp.#:Mode		• off • on • test	on
Superv. signal				
_:104	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:105	Superv.Grp.#:Binary input		1 to 256	1
_:102	Superv.Grp.#:Enable variable group		• 0 • 1	false
Superv.gr. grp. start				
_:106	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:107	Superv.Grp.#:Binary input		1 to 256	1

Addr.	Parameter	C	Setting Options	Default Setting
Superv.gr. grp. end				
_:108	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:109	Superv.Grp.#:Binary input		1 to 256	1

8.3.3.6 Information List

No.	Information	Data Class (Type)	Type
Superv.Grp. #			
_:52	Superv.Grp.#:Behavior	ENS	O
_:55	Superv.Grp.#:Sig. volt. disturbed	SPS	O

8.3.4 Voltage-Transformer Circuit Breaker

8.3.4.1 Overview of Functions

The Voltage-transformer circuit breaker function detects the tripping of the voltage-transformer circuit breaker due to short circuits in the voltage-transformer secondary circuits.

The Voltage-transformer circuit breaker function works independently of Measuring-voltage failure detection and should be used – if possible – in parallel to it.

The tripping of the voltage-transformer circuit breaker has an impact on the quality of the recorded measured-value data (see chapter [illegible] Processing Quality Attributes).

For the following functions the reaction (blockout block) can be set within the function in cases of a tripping of the voltage-transformer circuit breaker:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Overvoltage protection with 3-phase voltage
- Overvoltage protection with positive-sequence voltage
- Overvoltage protection with any voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with any voltage

8.3.4.2 Structure of the Function

The Figure 8-[illegible] shows the position of the function in the device. Every voltage measuring point contains the Voltage-transformer circuit breaker function.

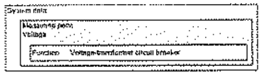


Figure 8-10 Structural Embedding of the Function

8.3.4.3 Function Description

The tripping of the voltage transformer circuit breaker is captured via the binary input signal >Open. With an active input signal the information about the measuring-voltage failure is relayed to the affected functions (see 8.3.4.1 Overview of Functions). The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

Response Time of the Voltage-Transformer Circuit Breaker

The response time of the voltage transformer circuit breaker can be slower than the pickup time of the distance protection. This bears the risk of an overfunction. The response time is communicated to the device with the Response time parameter. For a timely detection of the tripping of the voltage-transformer circuit breaker, the pickup of the distance protection is delayed by that response time.

8.3.4.4 Application and Setting Notes

The function is always active and need not be switched on.

Input Signal: >Open

- Input signal: (_:500) >Open

The input signal >Open must be connected to the tripping of the voltage transformer circuit breaker. As a rule, this occurs via the routing to a binary input.

Parameter: Response time of the voltage-transformer circuit breaker

- Recommended setting value (_:101) Response time = 0 ms

When the voltage-transformer circuit breaker drops out, the device must block the distance protection immediately to prevent an unwanted tripping of the distance protection due to the absence of the measuring voltage while the load current is flowing.

The blocking must be faster than the 1st stage of the distance protection. This requires an extremely short response time of the miniature circuit breaker (≤ 4 ms at 50 Hz, ≤ 3 ms at 60 Hz rated frequency). If the circuit-breaker auxiliary contact does not fulfill this requirement, you have to set the response time accordingly.

8.3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
VT miniatureCB				
_:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

8.3.4.6 Information List

No.	Information	Data Class (Type)	Type
Default set #			
_:500	VT miniatureCB:>Open	SPS	I

8.3.5 Voltage-Balance Supervision

8.3.5.1 Overview of Functions

In healthy system operation, a certain balance between voltages can be assumed.

The Voltage-balance supervision function detects the following errors:

- Unbalance of phase-to-phase voltages in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The voltage measurement is based on the RMS values of the fundamental component.

8.3.5.2 Structure of the Function

The Voltage-balance supervision function is located in the Power-system data of each 3-phase voltage measuring point.

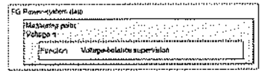


Figure 8-11 Structural Embedding of the Function

8.3.5.3 Function Description

The voltage balance is checked by a magnitude supervision function. This function relates the smallest phase-to-phase voltage to the largest phase phase-to-phase voltage. Unbalance is detected if |Vmin| / |Vmax| < Threshold min/max, as long as Vmax > Release threshold.

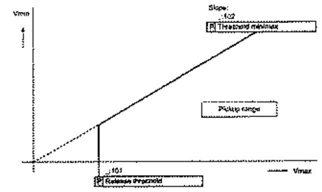


Figure 8-12 Characteristic of the Voltage-Balance Supervision

Logic

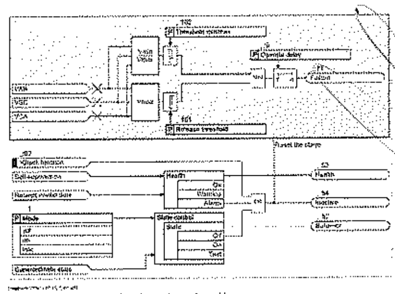


Figure 8-13 Logic Diagram of the Voltage-Balance Supervision

The Threshold min/max parameter is the criterion by which a phase-to-phase voltage unbalance is measured. The device calculates the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage.

Enter the lower limit of the maximum phase-to-phase voltage (V_{max}) with the parameter Release threshold. This specifies the lower limit of the operating range of the function.

Operate delay

If it falls below the balance factor Threshold min/max and at the same time the maximum phase-to-phase voltage exceeds the Release threshold, the Operate delay begins. If both conditions persist during this time, the indication Failure is generated.

8.3.5.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value (_:102) Threshold min/max = 0.75

The Threshold min/max parameter is used to set the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltages. Siemens recommends using the default setting.

Parameter: Release threshold

- Recommended setting value (_:101) Release threshold = 50 V

With the Release threshold parameter you set the lower limit of the maximum phase-to-phase voltage (V_{max}). Siemens recommends using the default setting.

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

Set the Operate delay parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

8.3.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. V				
_:1	Supv. balan. V:Mode		• off • on • test	off
_:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75
_:6	Supv. balan. V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.5.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. V			
_:82	Supv. balan. V:>Block function	SPS	I
_:54	Supv. balan. V:Inactive	SPS	O
_:52	Supv. balan. V:Behavior	ENS	O
_:53	Supv. balan. V:Health	ENS	O
_:71	Supv. balan. V:Failure	SPS	O

8.3.6 Voltage-Sum Supervision

8.3.6.1 Overview of Functions

In healthy system operation, the sum of all voltages at one measuring point must be approximately 0. The Voltage-sum supervision monitors the sum of all voltages of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit. For summation of the voltages, the 3 phase-to-ground voltages and the residual voltage (da-dn - voltage of an open circuited delta winding) are required.

The voltage measurement is based on the RMS values of the fundamental component.

> **NOTE**
>
> For the Voltage-sum supervision, the externally generated residual voltage must be connected to the 4th voltage measuring input.
>
> For the Voltage-sum supervision to work correctly, the Matching ratio Vph / VN parameter must be set accordingly.

8.3.6.2 Structure of the Function

The Voltage-sum supervision function is located in the Power-system data function group of each 3-phase voltage measuring point.

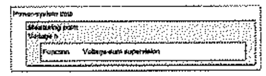


Figure 8-14 Structural Embedding of the Function

8.3.6.3 Function Description

The voltage sum is generated by addition of the voltage phasors. Errors in the voltage circuits are detected if $V_F = |V_A + V_B + V_C + V_{ph}/V_N \cdot V_N|$ > Threshold, where Vph/VN forms the Matching ratio Vph / VN parameter.

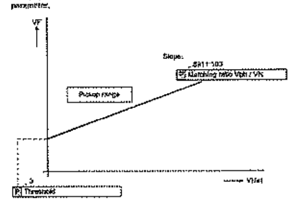


Figure 8-15 Characteristic of the Voltage-Balance Supervision

Logic

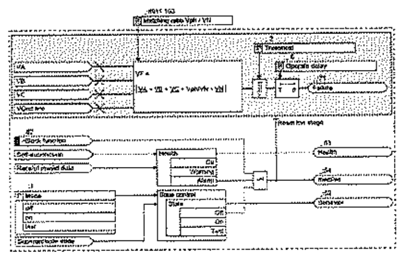


Figure 8-16 Logic Diagram of the Voltage-Sum Supervision

The device measures the phase-to-ground voltage and the ground voltage of the lines to be protected. The sum of the 4 voltages must be 0.

Threshold

If the calculated fault voltage (V_F) exceeds the Threshold, the parameter Operate delay triggers the indication Failure.

The device calculates the fault voltage (V_F) with the formula

$V_F = |V_A + V_B + V_C + V_{ph}/V_N \cdot V_N|$, where Vph/VN forms the Matching ratio Vph / VN parameter.

The Matching ratio Vph / VN parameter takes into account the differing transformation ratios between the residual voltage input and the phase voltage inputs.

More information in this regard can be found in chapter 6.x.x Overview of Functions.

Operate delay

When the threshold value for the Operate delay is exceeded, the indication Failure is generated.

8.3.6.4 Application and Setting Notes

Parameter: Threshold

- Recommended setting value (_:3) Threshold = 25 V

The Threshold parameter is used to set the voltage which the device uses to recognize the calculated fault voltage (V_F) as a failure of the voltage sums. Siemens recommends using the default setting.

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 3.00 s

Set the Operate delay parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

8.3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum V				
_:1	Supv. sum V:Mode		• off • on • test	off
_:3	Supv. sum V:Threshold		0.300 V to 170.000 V	43.300 V
_:6	Supv. sum V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.6.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum V			
_:82	Supv. sum V:>Block function	SPS	I
_:54	Supv. sum V:Inactive	SPS	O
_:52	Supv. sum V:Behavior	ENS	O
_:53	Supv. sum V:Health	ENS	O
_:71	Supv. sum V:Failure	SPS	O

8.3.7 Voltage Phase-Rotation Supervision

8.3.7.1 Overview of Functions

The Voltage phase-rotation supervision function monitors the phase sequence of the secondary-circuit voltages by monitoring the sequence of the zero crossings (with same sign) of the voltages. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the Phase sequence parameter.

8.3.7.2 Structure of the Function

The Voltage phase-rotation supervision function is located in the Power-system data of each 3-phase voltage measuring point.

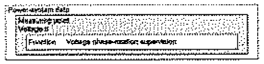


Figure 8-17 Structure/Embedding of the Function

8.3.7.3 Function Description

Logic

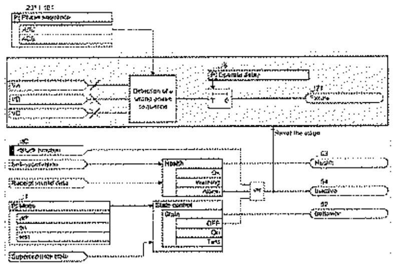


Figure 8-18 Logic Diagram for the Voltage Phase-Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.

You can find detailed information in the section Power-system data.

The phase rotation is important for protection functions which process phase, loop, and directional information. The connection of the currents to the device does not depend on the selected phase sequence.

The connection diagrams are shown in the section Appendix.

Operate delay

When the device detects an inverted phase-rotation direction for the duration of the Operate delay, the indication Failure is generated.

8.3.7.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

Set the Operate delay parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

8.3.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph.seq. V				
_:1	Supv. ph.seq. V:Mode		• off • on • test	off
_:6	Supv. ph.seq. V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.7.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph.seq. V			
_:82	Supv. ph.seq. V:>Block function	SPS	I
_:54	Supv. ph.seq. V:Inactive	SPS	O
_:52	Supv. ph.seq. V:Behavior	ENS	O
_:53	Supv. ph.seq. V:Health	ENS	O
_:71	Supv. ph.seq. V:Failure	SPS	O

8.3.8 Current-Balance Supervision

8.3.8.1 Overview of Functions

In healthy network operation, a certain balance between currents can be assumed.

The Current-balance supervision function detects the following errors:

- Unbalance of phase currents in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The current measurement is based on the RMS values of the fundamental component.

8.3.8.2 Structure of the Function

The Current-balance supervision function is located in the Power-system data of each 3-phase current measuring point.

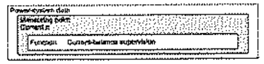


Figure 8-19 Structure/Embedding of the Function

8.3.8.3 Function Description

The current balance is checked by a magnitude monitoring function. This function relates the smallest phase current to the largest phase current. Unbalance is detected if

|Imin| / |Imax| < Threshold min/max, as long as Imax > Release threshold / IN.

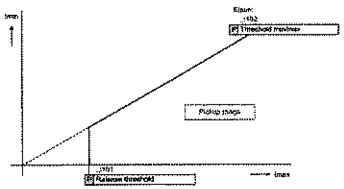


Figure 8-20 Characteristic of the Current-Balance Supervision

Logic

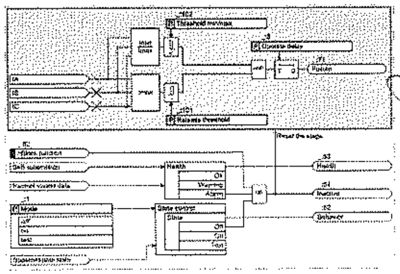


Figure 8-21 Logic Diagram of the Current-Balance Supervision

The Threshold min/max parameter is the criterion by which unbalance in the phase currents is measured. The device calculates the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Enter the lower limit of the maximum phase current (I_{max}) with the parameter Release threshold. This specifies the lower limit of the operating range of this function.

Operate delay

If it falls below the balance factor Threshold min/max and at the same time the maximum phase current exceeds the Release threshold, the tripping delay begins. If both conditions persist during this time, the indication Failure is generated.

8.3.8.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value (_:102) Threshold min/max = 0.5

The Threshold min/max parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Parameter: Release threshold

- Recommended setting value (_:101) Release threshold = 0.5 A for I_{rated} = 1 A or 2.5 A for I_{rated} = 5 A

The Release threshold parameter is used to set the lower limit of the maximum phase current (I_{max}).

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

Set the Operate delay parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

8.3.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. I				
_:1	Supv. balan. I:Mode		• off • on • test	off
_: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
_:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:6	Supv. balan. I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.8.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. I			
_:82	Supv. balan. I:>Block function	SPS	I
_:54	Supv. balan. I:Inactive	SPS	O
_:52	Supv. balan. I:Behavior	ENS	O
_:53	Supv. balan. I:Health	ENS	O
_:71	Supv. balan. I:Failure	SPS	O

8.3.9 Current-Sum Supervision

8.3.9.1 Overview of Functions

In healthy system operation, the sum of all currents at one measuring point must be approximately 0. The Current-sum supervision monitors the sum of all currents of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit.

For summation of the currents, the device requires the phase currents and the ground current of the current transformer neutral point or of a separate ground-current transformer at this measuring point. The following connection variants are available:

- Current-transformer connections connected to 3 current transformers and the neutral point (see Figure A-13 in the Attachment)
- Ground current detected with 3 separate ground current transformers (see Figure A-15 in the Attachment)
- 3 current transformers and one summation current transformer connected (see Figure A-14 in the Attachment)
- 2 current transformers and one summation current transformer connected (see A.4 Connection Examples for Current Transformers in the Attachment)

NOTE

For current-sum supervision, the ground current of the line to be protected must be connected to the 4th current measurement input (I_4).

8.3.9.2 Structure of the Function

The Current-sum supervision function is located in the Power-system data of each 3-phase current measurement point.

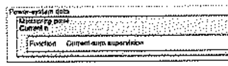


Figure 8-22 Structure/Embedding of the Function

8.3.9.3 Function Description

The current sum is generated by addition of the current phasors. Errors in the current circuits are detected if

IF = |IA + IB + IC + kI·IN| > Threshold + Slope factor · Σ |I|

356

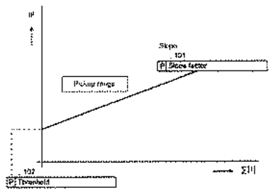


Figure 8-23 Characteristic of the Current-Sum Supervision

Logic

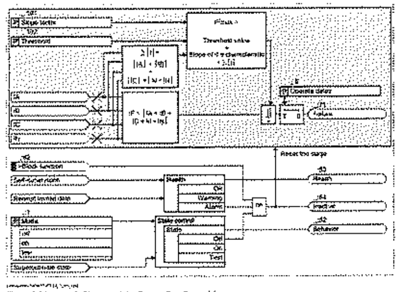


Figure 8-24 Logic Diagram of the Current-Sum Supervision

Slope of the Characteristic Curve

The Slope factor · Σ|I| part takes into account permissible current-proportional transformation errors of the transformer, which can occur in the case of high short-circuit currents.

The Slope factor and Threshold parameters are used to set the fault-current limit ($I_{F,Lim}$) for the current-sum supervision. The device calculates the fault current limit with the formula:

$I_{F,Lim}$ = Threshold + Slope factor · Σ|I|

The device uses the current inputs (IA, IB, IC and IN) to calculate:

- The fault current I_F = |IA + IB + IC + k_I · IN|
- The maximum current Σ|I| = |IA| + |IB| + |IC| + k_I · |IN|

with k_I taking into account a possible difference from the transformation ratio of a separated ground current transformer (I_N), for example cable-type current transformer.

- Transformation ratio of residual current converter $Ratio_N$
- Transformation ratio of phase current converter $Ratio_{ph}$

$$k_I = \frac{Ratio_N}{Ratio_{ph}}$$

Threshold

The Threshold parameter is the lower limit of the operating range of the Current-sum supervision function.

Operate delay

When the calculated fault current (I_F) exceeds the calculated fault current limit ($I_{F,Lim}$), the Operate delay starts. If the threshold-value violation persists for that time, the Failure indication is generated.

8.3.9.4 Application and Setting Notes

Parameter: Slope factor

- Recommended setting value (_:101) Slope factor = 0.1

The Slope factor parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current. The function calculates the RMS values.

Parameter: Threshold

- Recommended setting value (_:102) Threshold = 0.1 A for I_{rated} = 1 A or 0.5 A for I_{rated} = 5 A

The Threshold parameter is used to set the maximum phase current (I_{max}).

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

Set the Operate delay parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided.

8.3.9.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum I				
_:1	Supv. sum I:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:102	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
_:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:6	Supv. sum I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.9.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum I			
_:82	Supv. sum I:>Block function	SPS	I
_:54	Supv. sum I:Inactive	SPS	O
_:52	Supv. sum I:Behavior	ENS	O
_:53	Supv. sum I:Health	ENS	O
_:71	Supv. sum I:Failure	SPS	O

8.3.10 Current Phase-Rotation Supervision

8.3.10.1 Overview of Functions

The Current phase-rotation supervision function monitors the phase sequence of the secondary-circuit currents by monitoring the sequence of the zero crossings (with same sign) of the currents. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the Phase sequence parameter.

The current measurement is based on the RMS values of the fundamental component.

8.3.10.2 Structure of the Function

The Current phase-rotation supervision function is located in the Power-system data of each 3-phase current measurement point.

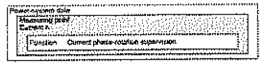


Figure 8-25 Structure/Embedding of the Function

8.3.10.3 Function Description

Logic

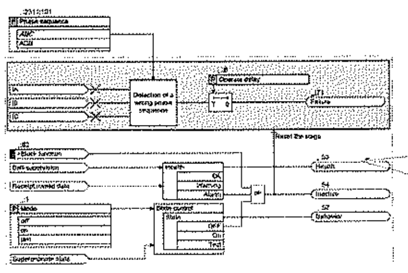


Figure 8-26 Logic Diagram Current Phase-Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.

You can find detailed information in the section Power-system data.

The phase rotation is important for protection functions which process phase, loop, and directional information. The connection of the currents to the device does not depend on the selected phase sequence.

The connection diagrams are shown in the section Appendix.

Operate delay

When the device detects an incorrect phase sequence for the duration of the Operate delay the indication Failure is generated.

8.3.10.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

Set the Operate delay parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

8.3.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph. seq. I				
_:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:6	Supv. ph.seq.I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.10.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph. seq. I			
_:82	Supv. ph.seq.I:>Block function	SPS	I
_:54	Supv. ph.seq.I:Inactive	SPS	O
_:52	Supv. ph.seq.I:Behavior	ENS	O
_:53	Supv. ph.seq.I:Health	ENS	O
_:71	Supv. ph.seq.I:Failure	SPS	O

8.3.11 Trip-Circuit Supervision

8.3.11.1 Overview of Functions

The Trip-circuit supervision function recognizes disruptions in the trip circuit. When 2 binary inputs are used, the function recognizes all disruptions in the trip circuit. If only 1 binary input is available, it will not recognize disruptions at the circuit breaker.

The control voltage for the circuit breaker must be greater than the sum of the minimum voltage drops at the binary inputs U_{St} > 2 U_{BImin}. At least 19 V are required for each binary input. This makes the supervision usable only with a system-side control voltage of > 38 V.

8.3.11.2 Structure of the Function

The trip-circuit supervision is integrated into the Circuit-breaker function group. Depending on the number of available binary inputs, it works with 1 or 2 binary inputs.

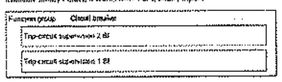


Figure 8-27 Structure/Embedding of the Function

8.3.11.3 Trip-Circuit Supervision with 2 Binary Inputs

In order to recognize disruptions in the trip circuit for each switch position, you need 2 binary inputs. One input is connected parallel to the respective command relay of the protection, the other parallel to the circuit-breaker auxiliary contact.

The following figure shows the principle of the trip-circuit supervision with 2 binary inputs.

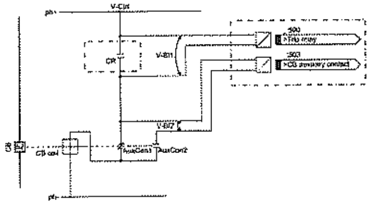


Figure 8-28 Principle of Trip-Circuit Supervision with 2 Binary Inputs

CR	Command relay
CB	Circuit breaker
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (NO)
AuxCon2	Circuit-breaker auxiliary contact (NC)
V-Ctrl	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2

Supervision with 2 binary inputs identifies disruptions in the trip circuit and the outage of the control voltage. It also monitors the reaction of the circuit breaker by way of the position of the circuit-breaker auxiliary contacts.

Depending on the switch position of the command relay and circuit breaker, the binary inputs are either activated (H) or not (L). If both binary inputs are not activated, there is a fault. The fault may be an interruption or a short circuit in the trip circuit, an outage of the battery voltage or a fault in the mechanics of the circuit breaker. With intact trip circuits, this state will occur only briefly while the command relay is closed and the circuit breaker has not yet been opened.

No.	Command Relay (CR)	CB	AuxCon1	AuxCon2	BI 1	BI 2	Dynamic State	Static State
1	Open	ON	Closed	Open	H	L	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	H	CR successfully activated the circuit breaker	

With the Alarm delay parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

357

If the binary input signals >Trip relay and >CB auxiliary contact are not routed on the binary inputs of the device, then the Input sig. not routed indication is generated and the Trip-circuit supervision function is not in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 2 binary inputs.

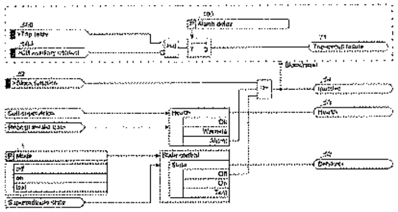


Figure 8-29 Logic Diagram of Trip-Circuit Supervision with 2 Binary Inputs

8.3.11.4 Trip-Circuit Supervision with 1 Binary Input

When using 1 binary input, you will not identify any disruptions on the circuit breaker. The binary input is connected in parallel with the respective command relay of the protection device. The circuit-breaker auxiliary contact is bridged with a high-resistance equivalent resistance R.

The following figure shows the principle of the trip-circuit supervision with 1 binary input.

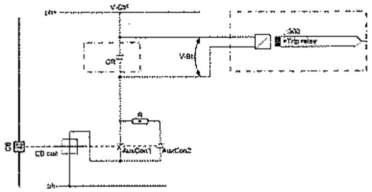


Figure 8-30 Principle of Trip Circuit Supervision with 1 Binary Input

CR	Command relay
CB	Circuit breaker
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (NC)
AuxCon2	Circuit breaker auxiliary contact (NO)
V Ctrl	Control voltage (tripping voltage)
VBI	Input voltage for binary input
R	Equivalent resistance

The supervision with 1 binary input identifies disruptions in the trip circuit and the failure of the control voltage.

In normal operation, the binary input is activated with the command relay open and the trip circuit intact (H). The supervision circuit is closed with the equivalent resistance R or with the auxiliary contact AuxCon1 of the closed circuit breaker. The binary input is not activated while the command relay is closed (L). If the binary input is not activated for a prolonged time, there is a disruption in the trip circuit or the control voltage has failed.

No.	Command Relay	CB	AuxCon1	AuxCon2	BI	Dynamic State	Static State
1	Open	ON	Closed	Open	H	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	CR successfully activated the circuit breaker	

Use the parameter Blk.by trip/open cmd from to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip circuit supervision function:

- The Trip/open cmd. of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.

As long as the trip-circuit supervision function is blocked, the closed contact of the command relay does not cause a failure indication.

If the command contacts of other devices work in parallel on the trip circuit, the failure indication must be delayed. With the Alarm delay parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

If the binary input signal >Trip relay is not routed to a binary input of the device (information routing in DIGSI 5), then the Input sig. not routed indication is generated and Trip-circuit supervision is no longer in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 1 binary input.

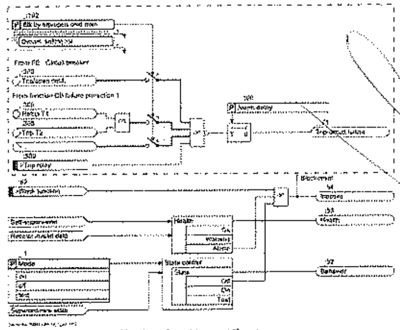


Figure 8-31 Logic Diagram of Trip-Circuit Supervision with 1 Binary Input

Equivalent Resistance R

The equivalent resistance R must be dimensioned such that the circuit breaker coil is no longer activated when the circuit breaker is open. Simultaneously, the binary input must still be activated when the command relay is open.

In order to ensure the minimum voltage for activating the binary input, R_{max} results in:

$$R_{max} = \left(\frac{V_{Ctrl} - V_{BImin}}{I_{BIHigh}}\right) - R_{CBC}$$

So that the circuit-breaker coil does not remain activated, R_{min} results in:

$$R_{min} = R_{CBC} \cdot \left(\frac{V_{Ctrl} - V_{CBC(Low)}}{V_{CBC(Low)}}\right)$$

You can calculate the optimal value for the equivalent resistance R from the 2 values R_{min} and R_{max}:

$$R = \frac{R_{min} + R_{max}}{2}$$

The following applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \cdot R = \left(\frac{V_{Ctrl}}{R + R_{CBC}}\right)^2 \cdot R$$

8.3.11.5 Application and Setting Notes

Parameter: Alarm delay

- Recommended setting value (_:100) Alarm delay = 2 s (Trip-circuit supervision with 2 binary inputs)
- Recommended setting value (_:100) Alarm delay = 300 s (Trip-circuit supervision with 1 binary input)

With the parameter Alarm delay, you can set the time for the delayed output of the indication Trip-circuit failure.

For Trip-circuit supervision with 2 binary inputs, you set the Alarm delay parameter so that the short-term transient states do not cause the function to activate.

For the Trip-circuit supervision with 1 binary input, you set the Alarm delay so that the longest duration of a trip command is bridged without fail. This ensures that the indication is emitted only if the trip circuit is actually interrupted.

Parameter: Blk.by trip/open cmd from

- Possible settings, application-dependent

The parameter works only with the trip-circuit supervision with 1 binary input.

Use the parameter Blk.by trip/open cmd from to set the conditions under which the trip circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

- The Trip/open cmd. of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.
- One of the trip commands of the circuit-breaker reignition protection is activated.

The circuit-breaker failure protection is set to protect a different trip circuit than the local circuit breaker. Using the configuration options of the Blk.by trip/open cmd from parameter, multiple trip-circuit supervision functions can be operated in parallel. For instance, a trip circuit supervision function dedicated to a local circuit breaker can also be operated parallel to a higher-level circuit breaker upon which the circuit-breaker failure protection acts.

8.3.11.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
74TC sup.1BI #				
_:1	74TC sup.1BI #:Mode		• off • on • test	on
_:100	74TC sup.1BI #:Alarm delay		1.00 s to 600.00 s	300.00 s
_:102	74TC sup.1BI #:Blk.by trip/open cmd from		Setting options depend on configuration	
74TC sup.2BI #				
_:1	74TC sup.2BI #:Mode		• off • on • test	on
_:100	74TC sup.2BI #:Alarm delay		1.00 s to 30.00 s	2.00 s

8.3.11.7 Information List

No.	Information	Data Class (Type)	Type
74TC sup.1BI #			
_:82	74TC sup.1BI #:>Block function	SPS	I
_:500	74TC sup.1BI #:>Trip relay	SPS	I
_:54	74TC sup.1BI #:Inactive	SPS	O
_:52	74TC sup.1BI #:Behavior	ENS	O
_:53	74TC sup.1BI #:Health	ENS	O
_:71	74TC sup.1BI #:Trip circuit failure	SPS	O
_:301	74TC sup.1BI #:Input sig. not routed	SPS	O
74TC sup.2BI #			
_:82	74TC sup.2BI #:>Block function	SPS	I
_:500	74TC sup.2BI #:>Trip relay	SPS	I
_:503	74TC sup.2BI #:>CB auxiliary contact	SPS	I
_:54	74TC sup.2BI #:Inactive	SPS	O
_:52	74TC sup.2BI #:Behavior	ENS	O
_:53	74TC sup.2BI #:Health	ENS	O
_:71	74TC sup.2BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.2BI #:Input sig. not routed	SPS	O

8.4 Supervision of the Device Hardware

8.4.1 Overview

The correct state of the device hardware is a requirement for the correct functioning of the device. The failure or erroneous function of a hardware component leads to device malfunctions.

The following modules of the device hardware are monitored:

- Base module
- Expansion modules
- Plug-in modules on the interface locations

The fault responses result, depending on type and degree of the error, as follows.

Hardware errors where the device remains in operation.

The error is indicated. The signal data affected by the failure are marked as invalid. In this way, the affected protection functions can switch into a secure state. Such errors are, for example:

- Communication-module failure (module x)
- Measuring transducer module failure (module x)
- USB interface
- Integrated Ethernet interface
- Real-time clock building block
- A/D converter (fast current sum)
- Battery voltage
- Faulty or missing compensation values (mean/udelphase)

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Memory error (RAM) in the base module
- Faulty module
- Module connection error (PCB link)
- Control circuit error binary output
- Outage of an internal auxiliary voltage

NOTE

If the error has not be rectified after 3 unsuccessful attempts, the system automatically recognizes it as a severe device malfunction. The device goes permanently out of operation into a secure state (fallback mode).

Fatal device errors with outage of central components: The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Memory error (Flash) in the base module
- CPU/Controller/FPGA error in the base module
- 3 unsuccessful restarts in a row

You can find the detailed description, in table form, of the list of responses at the end of chapter 8. You will find corresponding corrective measures there.

358

Device Operating Hours

The *Device operating hours* statistical value counts the operating hours of the physical device. The starting time and the time in fallback mode are not considered.

You can neither reset nor change the statistical value.

8.4.2 Analog-Channel Supervision via Fast Current-Sum

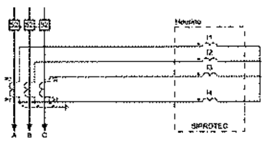
8.4.2.1 Overview of Functions

The function **Supervision of the device-internal analog-digital converters** performs the following tasks:

- Supervision of the correct functioning of the device-internal analog-digital converters, based on the sum of all currents at one measuring point in the secondary circuit.
- Detection of failures in the device-internal measuring circuits (for example, analog-digital converter)
- Blocking of protection and control functions that process the measured values from this current measuring point (for example, differential protection). This avoids an overfunction of the device.

The supervision principle is based on fast current sum supervision with connection of the neutral-point current to the 4th current measurement input, in order to ensure that even the fast tripping stages of the protection functions can be blocked in time before a spurious pickup. The fast current measurement is based on instantaneous values.

For **Analog-digital converter supervision**, the neutral-point current of the line to be protected must be connected to the 4th current measuring input (I_4). The 4th current measuring input must be routed via the current-transformer neutral point (I_4 neutral point) (see next figure).



Current transformer 3-phase: connection = 3-phase + IN

Figure 8-32 Connection to a 3-Phase Current Transformer and Measured Zero-Sequence Current (Current in Common Return Path)

> **NOTE**
>
> The analog channel supervision via fast current sum is only available when the 4th current input is a protection-class current transformer. In the DIGSI 5 project tree, under **Device → Measuring-point routing**, set the connection type **3-phase + IN** for the current measuring point.

8.4.2.2 Structure of the Function

The **Supervision of the device-internal analog-digital converters** function is located in the **Power system data** function group of each 3-phase current measuring point.

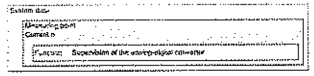


Figure 8-33 Structure/Embedding of the Function

8.4.2.3 Function Description

Errors in the current circuits are detected if

$I_F = |iA + iB + iC + iN| >$ Threshold value + Slope of the characteristic 1 · Σ|i| and

$I_F >$ Slope of the characteristic 2 · (Σ|i| − Base point 2)

With the current inputs (iA, iB, iC, and iN), the device calculates:

- The fault current $I_F = |iA + iB + iC + iN|$
- The maximum current $Σ|i| = |iA| + |iB| + |iC| + |iN|$

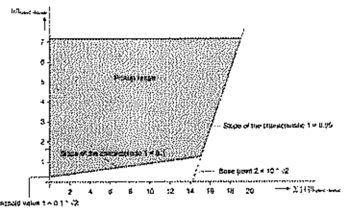


Figure 8-34 Characteristic Curve of the Supervision of the Device-Internal Analog-Digital Converters

Logic

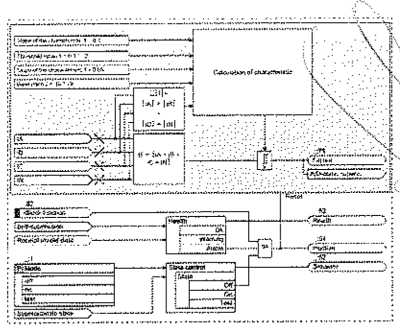


Figure 8-35 Logic Diagram of the Supervision of the Device-Internal Analog-Digital Converters

When the output signal A/D converter failure is active, certain protection functions are blocked to avoid failures (see 8.4.2 Analog-Channel Supervision via Fast Current-Sum).

> **NOTE**
>
> The parameters are fixed in the device and cannot be changed.
> It is not necessary to change the parameters depending on the application.

Threshold Value

The threshold value is the lower limit of the operating range of the **Supervision of the device-internal analog-digital converters** function.

The threshold value is fixed to 10 % of the device rated current.

Slope of the Characteristic 1

The component slope of **characteristic 1** · Σ|i| takes into account permissible current-input errors, which can occur in the case of small overcurrents.

The slope of characteristic 1 is fixed to 0.1.

Slope of the Characteristic 2

The component slope of **characteristic 2** takes into account permissible current-input errors, which can occur in the case of high overcurrents (high short-circuit currents).

The **slope of characteristic 2** is fixed to 0.95. The base point of the **slope of characteristic 2** is fixed to 10.

8.5 Supervision of Device Firmware

The device firmware determines essentially the functionality of the device.

The following supervisions ensure the stable function of the device:

- Supervisions of the data and version consistency
- Supervision of the uninterrupted sequential activity of the device firmware
- Supervision of the available processor performance

When you start the device, load data via the interfaces and these supervisions of the device firmware will be in effect during the continuous operation. Depending on the type and severity of error, the following error responses will result:

Firmware failures where the device remains in operation.

The error is indicated. The signals/data affected by the failure are marked as invalid. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in time synchronization (loss and errors).

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Device startup with faulty, new parameter set. The old parameter set is still present.
- Overloading of the processor
- Program-sequence error

Fatal firmware error. The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Device startup with faulty, new parameter set. No usable parameter set is present.
- Device startup with version error
- CFC runtime error
- 3 unsuccessful restarts in a row

You can find the detailed description, in table form, of the fault responses at the end of chapter 8. You will find corresponding corrective measures there.

8.6 Supervision of Hardware Configuration

The modular hardware concept requires adherence to some rules within the product family and the modular system. Configuration errors show that the hardware configuration saved in the device does not agree with the hardware actually detected. Impermissible components and unallowed combinations must be detected just as missing configured components are.

Depending on the type and severity of error, the following error responses will result: The identified hardware configuration errors are assigned to the defect severities as follows:

Configuration errors where the device remains in operation.

The failure is indicated. The signals/data affected by the failure are marked as invalid. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in IT converter configuration (loss and errors).

Fatal configuration error. The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Missing hardware module (module x)
- Incorrect hardware module (module x)
- Incorrect hardware combination
- Incorrect plug-in module (module x)

You can find the detailed description, in table form, of the error reactions at the end of chapter 8. You will find corresponding corrective measures there. You can resolve configuration errors through another system [illegible] with DIGSI.

359

8.7 Supervision of Communication Connections

SIPROTEC 5 devices offer extensive communication possibilities via fixed and optional interfaces. Beyond the hardware supervision of the communication plug-in modules the transferred data must be monitored with respect to their consistency, failure, or outage.

Supervision

With the supervision of the communication connections, every communication port is monitored selectively.

- Failures are detected and indicated via the operational log. The device remains in operation!
- Each port additionally is equipped with a separate communication log, with which details of the failures (for example, error rate) are displayed.

Marking Fault Signals/Data

The signals/data affected by the failure are marked as invalid. In this way, the affected protection functions can go into a secure state. In the following, some examples are named:

- GOOSE signals can automatically be set to defined values in case of disturbed IEC 61850 communication.
- Disturbed protection interfaces set phasor values, both analog measured values and binary information to invalid (for example, for differential protection). Binary signal states can be set to defined values in cases of failures.
- Disturbed time-synchronization signals can lead to an automatic change of the source of time synchronization.

Normally, you can correct communication failures by checking the external connections or by replacing the affected communication modules. In chapter 8.8.4 Defect Severity 3, you will find the detailed description, in tabular form, of the error responses. Corresponding corrective measures can also be found there.

8.8 Error Responses and Corrective Measures

8.8.1 Overview

When device errors occur and the corresponding supervision functions pick up, this is displayed on the device and also indicated. Device errors can also lead to corruption of data and signals. These data and signals are marked and tagged as invalid, so that affected functions automatically go into a secure state. If the supervision functions pick up, this will lead to defined error responses.

How Do Device Errors Make Themselves Noticeable

In case of a device error the supervision functions of the device pickup. The device responds according to the type and severity of the error. To report an error, supervision functions use outputs on the device and indications.

Run LED (green)	The external auxiliary voltage is present. The device is ready for operation.
Error LED (red)	The device is not ready for operation. The life contact is open.
Life contact	Signaling of device readiness following successful device startup.
Group-warning indication *Group warning*	The device remains in operation and signals an error via the prerouted LED and the log.
Log of the device	Indications of causes for defects and corrective measures

Determination of Causes for Defects and Corrective Measures

To determine the cause for defect and the corresponding corrective measure, proceed step by step.

Step 1: Pick up of supervisions leads to one of the following defect severities in all cases.

- **Defect severity 1:**
  Internal or external device error that is reported. The device stays in operation.
- **Defect severity 2:**
  Severe device failure, the device restarts (reset) to correct the cause for defect.
- **Defect severity 3:**
  Severe device failure, the device goes to a safe condition (fallback mode), as the correction of defects by a restart is not possible. In fallback mode, the protection and automatic functions are inactive. The device is out of operation.
- **Defect severity 4:**
  Severe device external failure, the device switches the protection and automatic functions to inactive for safety, but stays in operation. Normally, the user can correct the fault by himself.

Step 2: For every defect severity, you will find detailed tables with information about causes for defects, error responses, and corrective measures in the following chapters.

	Error Responses						
	Group-Warning Indication Group Warning	Indication in the Operational Log	Indication in the Device-Diagnosis Log	Indication of the Life Contact	All Protection and Automation Functions Are Inactive	Device Restart (Reset)	Fallback Mode
Defect severity 1	x	x	x				
Defect severity 2			x	x	During the starting time of the device	x	
Defect severity 3			x	x	x		x
Defect severity 4		x		x	x		

8.8.2 Defect Severity 1

Defect severity 1 faults allow the continued safe operation of the device. Defect severity 1 faults are indicated. The device remains in operation.

When the supervision functions pick up, corrupted data and signals are marked as invalid. In this way, the affected functions can go into a secure state. Whether functions are blocked is decided in the appropriate function itself. For more detailed information, refer to the function descriptions.

Live status contact	Remains activated
Red error LED	Is not activated

Log

For every device fault, a corresponding supervision indication is generated. The device records these indications with a real-time stamp in the operational log. In this way they are available for further analyses. If supervisions in the communication interfaces area of the device pick up, there is a separate communication log available for each port. Extended diagnostic indications and measured values are available there. The device-diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3.

Group-Warning Indication Group Warning

As delivered, all supervision indications of Defect Severity 1 are routed to the signal (_:301) Group warning. In this way, a device error can be indicated with only one indication. The majority of supervision indications are permanently connected to the Group warning indication (Group warning column = fixed). However, some supervision indications are routed flexibly to the Group warning via a CFC chart (Group warning column = CFC). If necessary, you can remove the routings via a CFC chart from the group indication. In delivery condition, the Group warning is prerouted to an LED.

You can find further information on handling the logs in chapter 3.

Overview of Errors

Indication	Type	Group Warning	Explanation
General: (_:53) Health	ENS		If the Health of an individual function block, for example, a protection stage or an individual function, goes to the *Warning* or *Alarm* state, this state is processed via the associated function group up to the general group indication Health (_:53). Check via the operational log from which function or function block the error originates. You can find additional information as to why the health of the function or a function block can change in the associated function description.
(_:53) Health = Warning	SPS		
(_:53) Health = Alarm	SPS		
Device: (_:326) AuxVolt.fault	SPS	Fixed	Fault with the auxiliary power supply: Check the external power supply.
Device: (_:305) Battery fault	SPS	Fixed	Battery fault: Replace the device battery.
Device: (_:312) Compensation fault x	ENS	Fixed	Calibration error in module x: Contact the Customer Support Center. Quality: Measured values are marked with the quality attribute of *questionable* (measured value display with –).
Device: (_:314) Offset error x	ENS	Fixed	Offset error on module x: If this indication persists after the device start, contact the Customer Support Center. Quality: Measured values are marked with the quality attribute of *questionable* (measured value display with –).
Device: (_:306) Time failure	SPS	Fixed	Internal time failure: • Check the time settings first. • Then replace the device battery. • If the fault is not remedied, contact the Customer Support Center. Quality: The internal clock is marked with the quality attribute of *Clock failure*
Device: (_:317) Memory fault	SPS	Fixed	Checksum (CRC) error in monitored memory areas of the device
Device: Measuring-transducer error (x)	ENS	Fixed	Hardware error on measuring transducer module in plug-in module position EIP/ANIP Contact the Customer Support Center.
Handling an alarm: (_:501) >Group warning	SPS	Fixed	Input signal for user-defined generation of the group warning
Time sync: (_:305) Time sync fault	SPS	Fixed	Time synchronization error, the timing master is faulty: • Check the external time source first. • Check the external connections. • If the fault is not remedied, contact the Customer Support Center. Quality: The internal clock is marked with the quality attribute of *Clock not synchronized*

Indication	Type	Group Warning	Explanation
Power-system data meas. point I-3ph:Supv. Sym I: (_:71) Failure	SPS	CFC	Current balance failure (see chapter 8.3.7.1 Overview of Functions)
Power-system data meas. point I-3ph:Supv. PhsSeq.I: (_:71) Failure	SPS	CFC	Failure of current phase-rotation reversal (see chapter 8.3.11.1 Overview of Functions)
Power-system data meas. point I-3ph:Supv. Sum I: (_:71) Failure	SPS	CFC	Failure of current sum (see chapter 8.3.9.1 Overview of Functions)
Power-system data meas. point V-3ph: Volt.Trans.Cir.B. (_:500) >Open	SPS	CFC	Voltage-transformer circuit breaker is open. Blocking: Appropriate functions are either blocked definitely or you can set the blocking individually.
Power-system data meas. point V-3ph: Supv. sym V: (_:71) Failure	SPS	CFC	Voltage balance failure (see chapter 8.3.5.1 Overview of Functions)
Power-system data meas. point V-3ph: Supv. PhsSeq.V: (_:71) Failure	SPS	CFC	Failure of voltage phase-rotation monitoring (see chapter 8.3.7.1 Overview of Functions)
Power-system data meas. point V-3ph: Supv. of Sum V: (_:71) Failure	SPS	CFC	Failure of voltage sum (see chapter 8.3.6.1 Overview of Functions)
2 devices prot. comm.: Protection interface x: (_:303) Open connection (_:316) Fault rate/min exceeded (_:317) Fault rate/h exceeded (_:318) Runtime exceeded (_:320) Runtime jump detected	SPS SPS SPS SPS SPS	CFC[1]	Protection interface connection defective: • Check the connections and the external communication infrastructure. • If the fault is not removed, contact the Customer Support Center. Transferred Signals: Faulty or not received telegrams are detected at the receive end and discarded. They do not result in failure of the applications. Configured binary signals are reset after a time that can be set.
Line 1: Meas.Volt.Fail detected: (_:300) Failure	SPS	CFC	Measuring-voltage failure detected: Check the external wiring. Blocking: Appropriate functions are either blocked definitely or you can set the blocking individually.
Line 1: Overcurrent 3ph #General, (_:2311:301) Emergency mode	SPS	CFC	3-phase overcurrent protection works as an emergency overcurrent protection. Main protection function is blocked.

8.8.3 Defect Severity 2

Faults of defect severity 2 are fatal device faults that lead to an immediate restart of the device (reset). This occurs when the device data is corrupted (for example, RAM memory). If a restart prevents restoration of data consistency, the device goes briefly out of operation, a failure is avoided.

[1] The indications are not prerouted in the CFC chart. The indications must be added to the CFC chart by the user.

Life contact	Is terminated during the restart
Red error LED	Is activated during the restart

NOTE

If the fault of defect severity 2 has not be been removed after 3 unsuccessful restarts (reset), the fault is automatically assigned to defect severity 3. The device will automatically turn to the fallback mode.

Log

For every device error with a subsequent restart (reset), only the restart can be detected in the operational log. The actual supervision indication is entered in the device-diagnosis log at the point in time of the fault detection and before the restart. These indications are recorded with a real-time stamp and are thus available for later analyses. The device diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3.

Overview of Errors

Number	Device-Diagnosis Log
876	Processor error on the base module: If the fault occurs numerous times, contact the Customer Support Center
830	FPGA hardware error on the base module: Contact the Customer Support Center.
834	Memory error (short term). Reset initiated.
3823	Program run error: If the fault occurs numerous times, contact the Customer Support Center
826	CPU overload: If the fault occurs numerous times, contact the Customer Support Center.
Miscellaneous	Internal firmware error. If the fault occurs numerous times, contact the Customer Support Center.

8.8.4 Defect Severity 3

Faults of defect severity 3 are fatal device faults that lead to device immediately going into the fallback mode. The signal (_:307) *Device* status goes to the Alarm state. The Warning state is not supported for this signal.

Fatal device errors are errors that cannot be resolved by a restart of the device. In this case, contact the Customer Support Center. The device goes permanently out of operation, a failure is avoided. In the fallback mode, minimal operation of the device via the on-site operation panel and DIGSI is possible. In this way, for example, you can still read out information from the device-diagnosis log.

Life contact	Is terminated in the fallback mode
Red error LED	Is activated in the fallback mode

Log

For every device error that immediately leads to entry into the fallback mode, entries from supervision messages and from the signal (_:307) *Device* into the operational log are not possible. The actual supervision indication is entered in the device diagnosis log at the point in time of the fault detection, that is, before entry into the fallback mode. These indications are recorded with a real-time stamp and are thus available for later analyses. The device-diagnosis log contains expanded fault descriptions. There, you are offered recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3.

360

Overview of Errors

Number	Device-Diagnosis Log
2892	Memory error (continuous) Contact the Customer Support Center.
4777, 5018-5028	Hardware failure of module 1-12: Contact the Customer Support Center.
4729	Device has error (repeated) • Check the module configuration and the module connections. • Contact the Customer Support Center.
4753	Incorrect hardware configuration: Synchronize the hardware configuration of the device with DIGSI.
5037-5048	Wrong module 1-12 detected Synchronize the hardware configuration of the device with DIGSI.
5011-5016	Identified wrong plug-in module on plug-in module position 1/2/3/4/P Synchronize the hardware configuration of the device with DIGSI.
	Wrong application configuration: Search for the cause in the operational log and load a valid configuration to the device.
5640, 4514	Data structure error: Contact the Customer Support Center.
956	Firmware version error: Contact the Customer Support Center.
2013, 2025	Signature error: Contact the Customer Support Center.
	CFC error: In DIGSI, check your CFC chart for the cause.
5050-5061	Binary output error in module 1 – 12: Contact the Customer Support Center.
5088, 5089	A missing display configuration was established. Synchronize the hardware configuration of the device with DIGSI.

8.8.5 Defect Severity 4 (Group Alarm)

Errors of defect severity 4 are not device failures in the classical meaning. These errors do not affect the device hardware and are not detected or reported by internal device supervision functions. The condition of the defect severity 4 – the group alarm – is set user-specifically by the binary input signal *(_:503) >Group alarm*. If the binary input signal is reset, the device is no longer in the *Group alarm* condition and all functions return to the normal operating state.

If the group alarm is generated, the device reacts as follows:

- The group indication *(_:300) Group alarm* is generated and recorded in the operational log.
- The life contact is terminated.
- The red Error LED is activated.
- All protection and automation functions are blocked.
- The device remains in operation, does not carry out any restart (reset), and does not switch to the safe condition (fallback mode).
- The signals managed internally are marked with the *invalid* quality attribute. Signals managed internally are, for example, measured values, binary input and output signals, GOOSE and CFC signals.

In the delivery condition, every device has the CFC chart Process mode inactive, that initiates the Group alarm (see chapter 8.9 *Group Indications and Predefined CFC Charts*).

Life contact	Is terminated in case of Group alarm
Red error LED	Is initiated in case of Group alarm

Log

The group indication *(_:300) Group alarm* is recorded in the operational log. Depending on the cause of the initiation, further information can be found in the operational log.

You can find further information on handling the logs in chapter 3.

8.9 Group Indications and Predefined CFC Charts

The following group indications are available:

- *(_:300) Group alarm*
- *(_:301) Group warning*
- *(_:302) Group indication*

You can find the signals in the DIGSI 5 project tree under Name of the device) → Information routing. In the operating range, you can find the signals under Alarm handling (see the following figure).

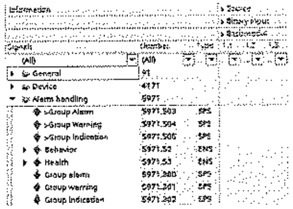


Figure 8.36 Group Monitoring Indication in the DIGSI 5 Information Routing Matrix

Group Indication Group Alarm

The indication *(_:300) Group alarm* is the group indication for defect-severity 4 monitoring. This monitoring has a special purpose, as it is set in a user-specific way by a binary input signal and not by internal device supervision. Nevertheless, the response of the device is serious, for example, the blocking of all protection and automatic functions (see chapter 8.8.5 Defect Severity 4 (Group Alarm)).

If the binary input signal *(_:503) >Group alarm* is set, the group indication *(_:300) Group alarm* is activated. If the binary input signal *(_:503) >Group alarm* is reset, the signal *(_:300) Group alarm* is also reset and the device returns to the normal operating state.

In the delivery condition, every device has the CFC chart Process mode inactive that initiates the *Group alarm*. This CFC chart checks whether the device is still accidentally in the simulation or commissioning mode.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under **Name of the device → Charts**.

Group Indication Group Warning

The indication *(_:301) Group warning* is the group indication for defect-severity 1 monitoring. Some error messages of defect severity 1 are firmly connected to the signal *(_:301) Group warning*, others are connected in a flexible way via a CFC chart in the device delivery condition. This allocation is described in chapter 8.8.2 Defect Severity 1.

In the delivery condition, every device has the CFC chart Group warning that initiates the *Group warning*.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under **Name of the device → Charts**.

The group-warning indication *(_:301) Group warning* is routed to an LED of the base module.

Group Indication

The *Group indication* is used only for user-specific purposes. There is no internal device supervision function that activates this indication. If the binary input signal *(_:505) >Group indication* is set, the indication *(_:302) Group indication* is activated and recorded in the operational log. In the delivery condition, there is no further response of the device. If the binary input signal is reset, the signal *(_:302) Group indication* drops out. You can define via a CFC chart when the binary input signal *(_:505) >Group indication* is to be set.

9 Measured Values, Energy Values, and Supervision of the Primary System

9.1 Overview of Functions

The measurands are recorded at the measuring points and forwarded to the function groups.

Within the function groups, further measurands are calculated from these measured values, which are required for the functions of this function group. This is how, for example, the electric power is calculated from the voltage and current measurands.

Measuring transducers are an exception as they already form various calculation parameters from the analog current and voltage inputs themselves.

Basic instructions for recording and editing process data can be found in the chapter 2.1 Function Embedding in the Device.

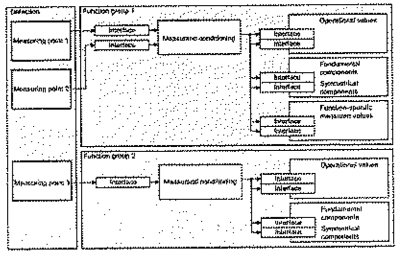


Figure 9.1 Structure of Measured Value Acquisition and Processing

For the display, the measured values of a SIPROTEC 5 device are summed up in the following groups:

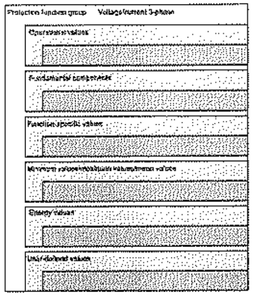
- Operational measured values
- Fundamental and symmetrical components
- Function-specific measured values
- Minimum values, maximum values, average values
- Energy metered values
- User-defined measured and metered values
- Statistic Values

9.2 Structure of the Function

Depending on the interconnection of the function groups, these can contain different measured-value groups. A typical function group is displayed below.

Voltage/Current 3-Phase Function Group Type

In the simplest version the Voltage/Current 3-phase function group obtains the measured values of the 3-phase voltage and current system and contains the following measured-value groups:

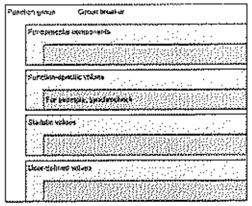


The Minimum values/Maximum values/Average values and User-defined values can be inserted from the library into the Voltage/Current 3-phase function group.

Details regarding the individual measured value groups can be found in the tables in the following chapters.

Circuit-Breaker Function Group

The Circuit breaker function group may contain the following measured values:



Inversion of Output-Related Measured and Statistical Values

The calculated, directional values in the operational measured values (power, power factor, energy and minimum, maximum, and average values based on these) are normally defined as positive in the direction of the protected object. This requires that the connection polarity for the measuring points used be correctly set (also compare (_:8881:116) Neutr.point in dir.of ref.obj parameter of the measuring point current, 3-phase). It is, however, possible, to set the "forward" direction for the protection functions and the positive direction for the powers, etc., differently, for example, such that the active power import (from the line to the busbar) is displayed positively. Then set the option P, Q sign in the affected function groups on the reversed parameter. With the parameter not reversed (default setting), the positive direction for the powers, etc., corresponds with the "forward" direction for the protection functions.

The affected values are given in detail in the Chapters 9.3 Operational Measured Values – 9.11.1 Statistical Values of the Primary System.

9.3 Operational Measured Values

Operational measured values are assigned to different function groups.

The values can be displayed as primary and secondary values and as percentage values.

The operational measured values are calculated according to the following definition equations.

RMS values

$$X = \sqrt{\frac{1}{T}\int_{t}^{t+T} x^2(t)dt}$$

Active power

$$P = \frac{1}{T}\int_{t}^{t+T} v(t)i(t)dt$$

Apparent power

$$S = \sqrt{3} \cdot V \cdot I$$

Reactive power

$$Q = \sum_{n} V_n \cdot I_n \cdot \sin(\varphi_n)$$

n Harmonic order

φ_n The angle difference between the voltage and current of the nth harmonic

Power factor

$$\lambda = \frac{|P|}{S}$$

Active power factor

$$\cos\varphi = \frac{P}{S}$$

Voltage/Current 3-Phase Function Group Type

The following table describes the operational measured values of the 3-phase voltage/current function group.

All protection functions have access to the values.

Table 9-1 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
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating 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	Calculated zero-sequence voltage	kV	V	Rated operating voltage of primary values/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	-	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	-	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	-	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$

Measured Values		Primary	Secondary	% Referenced to
Cos φ	Active power 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 $V_{rated\,phs} \cdot I_{rated\,phs}$

NOTE

With the P, Q sign parameter in the function block General of the respective function group, the sign of the following measured values can be inverted:

- 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

9.4 Fundamental and Symmetrical Components

The fundamental components are calculated from the frequency-tracked instantaneous values through a Fourier filter (integrating interval: one period). The results are phasor values that are described by way of the amount and phase angle.

In accordance with the transformation matrix, the symmetrical components are calculated from the voltage and current phasors. These are also phasor quantities.

Fundamental Components

Table 9-2 Fundamental Components

Values		Primary	Secondary	Phase Angle	% Referenced to
V_A, V_B, V_C	Phase to ground voltage	kV	V	°	Rated operating voltage of primary values/√3
V_N	Measured neutral-point displacement voltage	kV	V	°	Rated operating voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	°	Rated operating voltage of the primary values
I_A, I_B, I_C	Phase currents	A	A	°	Rated operating current of the primary values
I_N	Neutral-point phase current	A	A	°	Rated operating current of the primary values

Symmetrical Components

Table 9-3 Symmetrical Components

Values		Primary	Secondary	Phase Angle	% Referenced to
V_0	Zero-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
V_1	Positive-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
V_2	Negative-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
I_0	Zero-sequence component of the current	A	A	°	Rated operating current of the primary values
I_1	Positive-sequence component of the current	A	A	°	Rated operating current of the primary values
I_2	Negative-sequence component of the current	A	A	°	Rated operating current of the primary values

9.5 Phasor Measurement Unit (PMU)

9.5.1 Overview of Functions

A Phasor Measurement Unit (PMU) measures the phasor values of current and voltage. These values get a high precision time stamp and together with the values of power frequency, power frequency change rate and optional binary data that are also time stamped are transmitted to a central analysis station. The standardized transmission protocol IEEE C37.118 is used to do this.

9.5.2 Structure of the Function Group

The PMU function group is activated by selecting the protocol IEEE C37.118 PMU on an Ethernet module (electrical or optical). The PMU obtains the measured values from the measuring points and the precise time from time synchronization. The time-stamped synchrophasors for current and voltage are formed from this and transferred together with additional values via the communication module to a server (PDC, Phasor Data Concentrator).

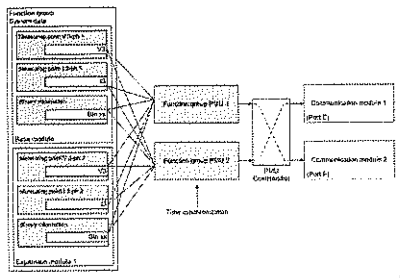


Figure 9-2 Structure/Embedding of the Function

9.5.3 Function Description

The synchrophasors, sent from the PMU in a continuous data stream to a PDC, are provided with time stamps and thus are comparable with the measured values of other PMUs. The power frequency, the power frequency change rate and optional binary information are also transmitted as time-stamped measured values. Therefore, you receive an overview of the transient processes in a distributed energy transfer system, for example network fluctuations and compensating processes.

The following table shows the differences between the PMU measured values and the remaining measured values of the device.

362

Table 9-4 Comparison of Synchrophasors and Conventional Measured Values

Synchrophasors of the PMU	Measured Values from the Measuring Points
Continuous updating (measured value of current with, for example, 10 values per second (reporting rate)	Slow updating (typically every 5 seconds)
Every measured value has a time stamp	No time stamp for the measured values
Phasor values of current and voltage (amplitude and phase angle)	RMS values without phase angle

The following figure shows the structure of such a Wide Area Monitoring System. The data delivered from the PMUs on the PDC are transmitted via the Inter-Control Center Communications Protocol (ICCP) according to DIN EN 60870-6 to the network control center.

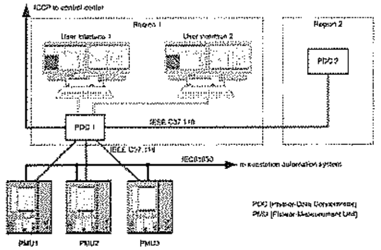


Figure 9-3 Structure of a Wide-Area Monitoring System with Phasor Measurement Units

The phasor measurement units each have 2 communication interfaces: an Ethernet module for synchrophasor communication via IEEE C37.118 and another module for communication with the substation automation technology, for example, through the IEC 61850 protocol.

The central evaluation system, e.g., SIGUARD PDP Phasor Data Processor, receives the data, files, archives them and graphically displays them on a user interface. In this system, a self-checking function may also be performed, for example, on undamped power swings. The further distribution of information to other PDCs or to a control station is done here.

To maintain the required maximum errors (TVE) required in the standard IEEE C37.118, the time tolerance relative to the UTC time reference (UTC – Universal Time Coordinated) may be maximum 10 µs. Therefore, the device must be directly synchronized with a GPS precise time signal for the correct function of the PMU.

Phasors

A phasor $\underline{v}(t) = \hat{V}e^{j\omega t}$ can be displayed as a phasor that moves counterclockwise in the complex plane at the angular frequency ω. Therefore, the voltage function $u(t) = \mathrm{Re}\{\underline{v}(t)\}$ is obtained as a projection of the phasor $\underline{v}(t)$ on the real axis.

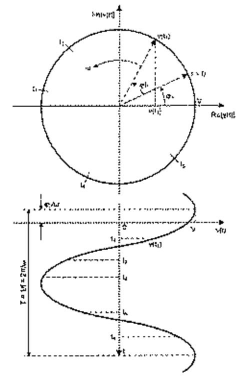


Figure 9-4 Geometric Representation of a Phasor

Reference Point for Determining the Angle

The phase angle of a measuring signal X_m is determined relative to a cosine function having a rated frequency, which is synchronized with the UTC time reference (see Figure 9-5).

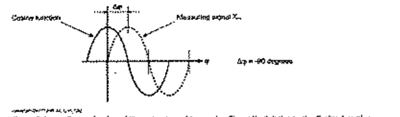


Figure 9-5 Determination of Phase Angle α of Measuring Signal X_m Relative to the Cosine Function

The number of phasors that are transmitted per second is configurable. The transmission rate is defined according to IEEE C37.118 as the reporting rate. The reporting rate defines the number of phasors that are transmitted per second. Extremely precise time synchronization is essential so that phasor measurement can be carried out to enable phasors from different sites to be compared.

Reporting Rate

You use the configurable reporting rate (parameter (_:10621:102) Reporting rate) to specify the number of telegrams that are computed and sent to the PDC per second. It is adjustable, depending on the rated frequency, and applies to all currents and voltages of the relevant PMU function group. If several PMU function groups are created on the device, these can work with different reporting rates.

Total Vector Error (TVE)

The TVE describes the error between the actual and the measured values of the input signal. The Synchrophasor Standard IEEE C37.118 defines upper limiting values at 120 % V_N and 200 % I_N among other things. Up to these limiting values, the TVE of 1 % must not be exceeded for stationary signals. The standard defines the 2 performance classes, Class P and Class M, as ranges within which influencing variables are acceptable and the TVE of <1 % must be maintained. The SIPROTEC 5 devices support Class P and Class M, which specify the following influencing variables for a TVE of 1 %:

- Signal frequency (relative to f_N)
- Signal magnitude (relative to 100 % nominal magnitude) for voltage and current
- Phase angle (relative to 0°)
- Harmonic distortions (relative to < 0.2 % (THD) up to the 50th harmonic

The following figure graphically represents the total vector error. As well as the amplitude, the TVE also enters into the angle error.

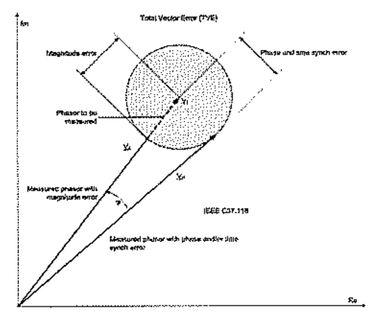


Figure 9-6 Representation of the Total Vector Error

The TVE is defined as follows.

$$TVE = \sqrt{\frac{(X_{r(n)} - X_r)^2 + (X_{i(n)} - X_i)^2}{X_r^2 + X_i^2}}$$

where,

- $X_{r(n)}$ = Real part of measured signal
- $X_{i(n)}$ = Imaginary part of measured signal
- X_r = Real part of input signal
- X_i = Imaginary part of input signal

Variables that influence the TVE are:

- Amplitude errors
- Phase errors
- Synchronization accuracy (deviation from the UTC)

Synchronization accuracy is affected by a GPS timer and the precise correction of the time delay within the GPS receiver module, as well as by the optimal setup of the GPS antenna.

9.5.4 Transmitted Data

The following data is transmitted from the PMU to the PDC:

- Current and voltage phasors
- Frequency
- Frequency rate of change
- Binary information

The current and voltage channels transferred from a PMU function group are selected through the Function group connections editor in DIGSI 5. The frequency and frequency change rate are determined once per PMU. In this case, only the current and voltage channels selected via the Function group connections editor for this PMU are taken into consideration. You may route the binary information in the information routing matrix of DIGSI 5.

The channel used for specifying the frequency is selected dynamically during the device runtime. Each channel is checked for the presence of a signal in the following order:

1. 3-phase voltage measuring points
2. 1-phase voltage measuring points
3. 3-phase current measuring points
4. 1-phase current measuring points

The 1st measuring point found with a valid signal is used for specifying the frequency in the PMU function group.

In the case of 3-phase measuring points, the positive-sequence system can also be transmitted instead of 3 individual synchrophasors. This setting can be made via the parameter (_:10621:103) Only positive sequence.

9.5.5 PMU Communication (IEEE C37.118)

PMU communication according to standard IEEE C37.118 is a client-server communication format in which the PDC (Phasor Data Concentrator) functions as both the client and the server.

Once the PDC has been successfully connected to the device PMU and the PMU configuration data has been queried, the PDC initiates transmission of the synchrophasor data by sending a start command to the PMU. In addition to the phasors, the channel names of the routed measuring points and the binary information are transferred. Per default, these are automatically generated by the respective PMU function groups.

Where applicable, you can also edit the channel names of the measuring point and assign a designation of its own for this purpose. For more information, see chapter 9.5.6 Parameterizing the PMU with DIGSI. The names for the binary information carried out are however, generally automatically generated by the respective PMU function group and cannot be edited.

As an example, the names (generated) for measuring points or binary information may be as follows:

Table 9-5 Function Measuring-Point Names

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point U-3ph 1 [ID 1]	MP-V3ph VAB ID01 MP-V3ph VBC ID01 MP-V3ph VCA ID01 MP-V3ph VA ID01 MP-V3ph VB ID01 MP-V3ph VC ID01 MP-V3ph V1 ID01

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point I-3ph 1 [ID 2]	MP-I3ph IA ID02 MP-I3ph IB ID02 MP-I3ph IC ID02 MP-I3ph I1 ID02
Measuring point I-1ph 1 [ID 3]	MP-I1ph ID03
Measuring point U-1ph 1 [ID 4]	MP-V1ph ID04

Table 9-6 Possible Binary Information Names

Path Displayed in DIGSI 5 (Can Be Edited)	Name Transferred to the PDC (Cannot be Edited)
PMU 1: Transf.bin.1: >Binaryinfo.6	BIN-01-INFO-6
PMU 1: Transf.bin.2: >Binaryinfo.8	BIN-02-INFO-8
PMU 1: Transf.bin.10 >Binaryinfo.3	BIN-10-INFO-3

Data is transmitted continuously from the PMU to the PDC at the configured reporting rate. The transmission is terminated by a corresponding switch off command from the PDC or when the connection between the PDC and the PMU is interrupted.

Communication between the PMU and the PDC can be passed via TCP or UDP protocols.

The following ports are used for data transmission:

- TCP: Port 4712
- UDP: Port 4713

The ports must be configured on the PDC.

Up to 3 different PDCs can be connected to one device PMU at the same time. The IP addresses of the maximum 3 PDCs are set in the PMU function group. If 4 device PMUs are configured, this enables support for up to 12 PDCs.

9.5.6 Parameterizing the PMU with DIGSI

You configure and parameterize the Phasor-Measurement Unit with DIGSI. After a device has been added in a DIGSI project, one or more communication modules that support synchrophasors can be configured as PMUs. The device module supports a maximum of 2 communication modules that can be configured as PMUs. If more than 2 PMUs are needed, the device must be expanded with a CB202 plug-in module assembly (expansion module), which can accommodate 2 more communication modules.

The following communication modules support synchrophasors:

- ETH-BA-2EL (2 x Ethernet electric, RJ45)
- ETH-BB-2FO (2 x Ethernet optical, 2 km, LC duplex)

These modules are then freely assignable to ports E, F, N or P of the device, see Figure 9-7. You can view the selected port in the (_:10621:104) Port. This parameter is automatically managed by DIGSI and cannot be changed.

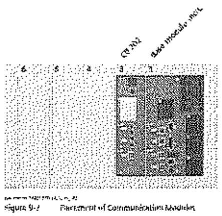


Figure 9-7 Placement of Communication Modules

NOTE

Port M of the CP202 plug-in module assembly is used to accommodate measuring-transducer modules and cannot be used for the installation of communication modules.

Addressing

You must configure the respective Ethernet address (IP address, subnet mask, etc.) for each communication module in DIGSI. This is done in the DIGSI General settings properties dialog of the communication module in Ethernet addresses and so forms the IP address for the respective PMU.

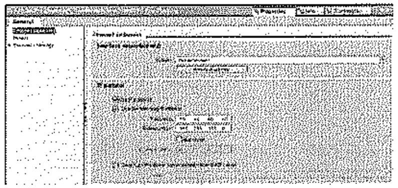


Figure 9-8 Ethernet Address Configuration

In the DIGSI properties dialog for channel 1, select the synchrophasor protocol, see the following figure.

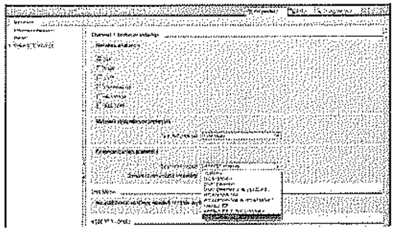


Figure 9-9 Protocol Selection

After you have selected the synchrophasor protocol for the communication module, an advanced settings dialog for PMU-specific configuration opens, see the following figure.

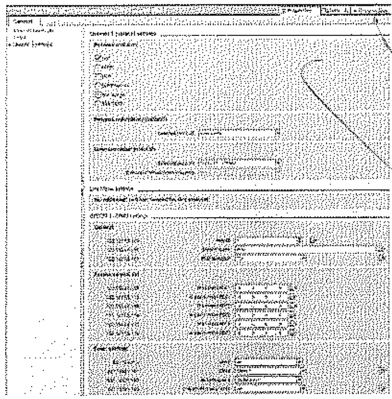


Figure 9-10 PMU-Specific Configuration

You configure the specific settings for the communication protocol in the top section of this settings dialog. In the bottom section, you specify the corresponding PMU-specific settings.

In order to permit a better configuration of larger wide area supervision systems, changes have been implemented in the IEEE C37.118 communication configuration that permit a flexible IP configuration without the loss of safety aspects in the systems administrated.

Configurable placeholders are permitted for each PDC IP address. These placeholders allow you to define a range of IP addresses where they are accepted within these addresses. The purpose of this is to permit each individual device or system access within the respective system without limits with regard to their hierarchy level. Therefore, with regard to security aspects, the limitation to individual IP addresses is eliminated. You are thus allowed to configure complete sections of IP addresses in each PMU and, as a result, very flexible when making changes to the configuration of the entire system, for example. The placeholder character must follow consecutively at the bit level, starting with the bit with the lowest value.

EXAMPLE of Placeholder Characters:

Example 1:

- binary 00000000.00000000.00000000.00101011 is not permitted
- binary 00000000.00000000.00000000.00111111 is permitted

Example 2:

- The PDC IP address is 192.172.16.1
- Placeholder: 0.0.0.127

The device accepts requests within the IP address range of 192.172.16.1 to 192.172.16.127.

Example 3:

- The PDC IP address is 192.172.16.100
- Placeholder: 0.0.0.3

The device accepts requests within the IP address range of 192.172.16.100 to 192.172.16.103.

If a PDC attempts to establish a connection to the device, the PDC IP addresses and corresponding placeholders are checked in the same order as they had been configured (IP address PDC1, IP address PDC2, IP address PDC3). Running through the list is stopped with the first match of the IP address, placeholder and requested IP address range and the connection is built up. If there are no matches, the attempt to connect is rejected.

If you have configured IP address 0.0.0.0 and the placeholder 255.255.255.255, every IP address received is accepted as valid. This could be of use in the course of commissioning measures.

NOTE

You must have configured at least 1 IP address in order to establish a connection between the device and PDC.

Measuring-Point Assignment

After adding measuring points to the device, you can assign these measuring points to each configured PMU. Figure 9-11 shows as an example expansion of the device configuration by 2 additional input/output modules. You connect the current and voltage inputs of these I/O modules to measuring points via the DIGSI routing matrix, see example in Figure 9-12.

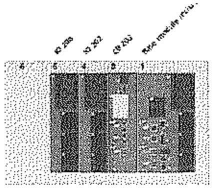


Figure 9-11 Adding Additional Input/Output Modules

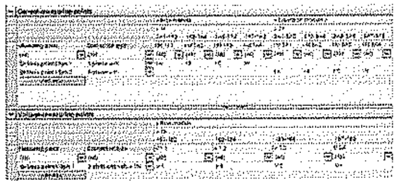


Figure 9-12 Assignment of the Current and Voltage Inputs of the Added Input/Output Modules on Measuring Points

The maximum numbers of measuring points that can be routed for one PMU are:

- 2 x 3-phase voltage measuring points
- 2 x 3-phase current measuring points
- 2 x 1-phase voltage measuring points
- 2 x 1-phase current measuring points

You can assign all supported measuring points to any PMU, see the following figure. However, each PMU must be connected to a 3-phase voltage measuring point.

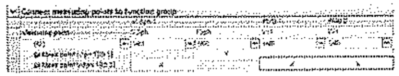


Figure 9-13 Connecting Measuring Points to the Configured PMU Function Groups

When these setting steps have been completed, the PMUs are fully configured. The PMU is a function group that functions independently of all the other function groups instantiated in the device.

The device load, however, is dependent on

- Number of PMUs
- Performance class (where Class M generates the greater load)
- Number of assigned channels
- Configured reporting rate of each PMU
- Number of binary signals to be transferred

Changing the Channel Names of Phasors

You can edit the names of the individual phasor channels for voltage and current in DIGSI. The clearly structured channel designations assist with when testing and commissioning PMU systems. Furthermore, only the names visible in the IEEE C37.118 interface can be changed. The function block designations themselves cannot.

The IEEE C37.118 defines the ASCII character set for changing the channel names in the scope of the SIPROTEC 5-PMU support. Due to the protocol, the designation length is limited to 16 ASCII characters per channel. However, when renaming, you have to assign at least 1 character. The renaming of binary channels is not supported in the current implementation.

You can start the renaming by setting the check mark at Own phasor names with the parameterization in the PMU function block, Functional settings. Once you have activated this check mark, define a separate name for each phasor. For this purpose, DIGSI shows all routed measuring points on the PMU in the function group connections (see following figure).

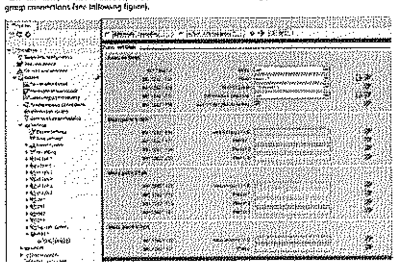


Figure 9-14 Options for Editing the Names of the Individual Phasors

NOTE

You can only rename each individual phasor when you set the parameter Own phasor names to yes. Otherwise you will only be offered one single phasor for each 3-phase measuring point for renaming.

Routing Binary Signals

You can connect binary inputs or CFC information with binary channels of the PMU via DIGSI information routing. You will find, in the Phasor Measurement Unit (PMU) folder, the Binary information transmission function block in the DIGSI function library (see the following figure). You can instantiate this function block up to 10 times in one PMU function group. Each of these function blocks contains 8 options for routing binary channels.

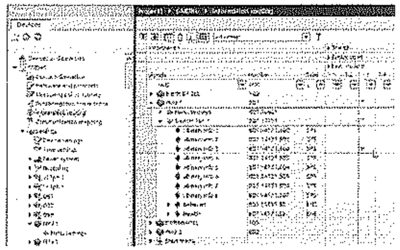


Figure 9-15 Information Routing in DIGSI 5

Routing Indications

The routable indication Channel 1 live of the PMU log

- raises when the PMU is connected to the PDC
- clears when the connection to the PDC is interrupted.

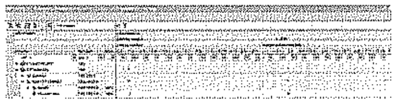


Figure 9-16 Log Indication for Display of the PMU/PDC Connection

9.5.7 Parameterizing the PMU on the Device

You can also change the PMU settings directly on the device. To do this, select the desired PMU instance on the device display. By selecting menu item Settings you then access the editable setting values (see Figure 9-17). Note that the parameter Port cannot be changed, because this corresponds to the physical slot position of the communication module in question.

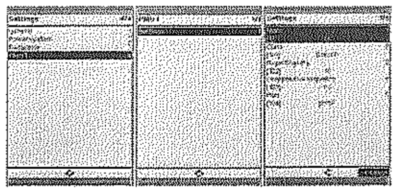


Figure 9-17 Changing the PMU Setting Values via the Device Display

You can also change the communication settings in the same way. To do this, select the corresponding communication port in the Communication menu on the device display. From the Channel 1 menu item, you can then access the detailed setting options for the IP or PMU communication settings (see Figure 9-18).

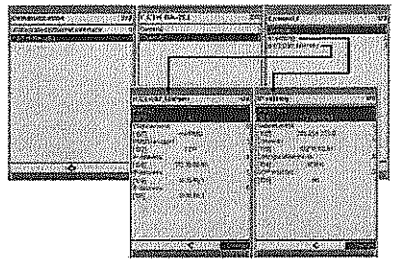


Figure 9-18 Changing the Communication Setting Values Via the Device Display

9.5.8 Application and Setting Notes

Time Synchronization

In order to ensure the time accuracy of the PMU, you must select IRIG-B as protocol for the GPS clock, see the following figure. With other settings, the PMU function function group indicates that it is not time synchronized.

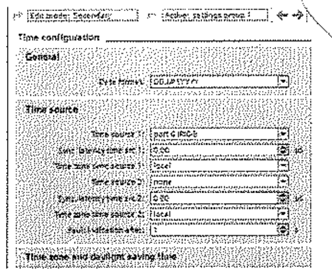


Figure 9-19 Setting Time Synchronization

To detect a lack of synchronization quickly, also set the waiting time for the failure indication of the loss of time synchronization to the smallest possible value, thus to 1 s.

Parameter: Mode

- Default setting (_:10621:1) Mode = on

Activate and deactivate the PMU or switch to Test mode via the parameter Mode. The possible setting values are on, off and test. In Test mode, the PMU data is marked as invalid.

Parameter: Reporting rate

- Default setting (_:10621:102) Reporting rate = 10 frames/s

With the parameter Reporting rate, you specify the number of telegrams that are compiled and sent to the PDC per second.

NOTE

Different setting values are shown or hidden, depending on the rated frequency set.

Parameter: Only positive sequence

- Default setting (_:10621:103) Only positive sequence = no

With the parameter Only positive sequence, you set whether the positive sequence system is to be transmitted instead of 3 individual synchrophasors in the case of 3-phase measuring points. The setting you make here is then valid for all PMUs with 3-phase measuring points.

Parameter: Class

- Default setting (_:10621:101) Class = Class P

With the setting Class, you set which performance class is used for the calculation of the measured values. Class P is the standard case for PMUs. In this case, filters are used that are suitable for a short response time and therefore are well suited for recording dynamic processes. Class M is conceived for applications that are unfavorably affected by alias effects and in which short response times are not relevant.

Parameter: Port

This parameter cannot be set because the Port results from the physical position where the corresponding communication module is inserted.

9.5.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Func. settings				
_:10621:1	Func. settings:Mode		• off • on • test	on
_:10621:101	Func. settings:Class		• Class P • Class M	Class P
_:10621:102	Func. settings:Reporting rate		• 1 frames/s • 5 frames/s • 6 frames/s • 10 frames/s • 12 frames/s • 15 frames/s • 20 frames/s • 25 frames/s • 30 frames/s • 50 frames/s • 60 frames/s • 100 frames/s • 120 frames/s	10 frames/s
_:10621:103	Func. settings:Only positive sequence		• no • yes	no
_:10621:104	Func. settings:Port		• port J • port F • port E • port P • port N • port G •	port F
_:10621:105	Func. settings:Customized phasor names		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Meas.point V-3ph				
_:10621:130	Func. settings:Measuring point ID		0 to 0	0
_:10621:131	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:133	Func. settings:Measuring point ID		0 to 0	0
_:10621:134	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:136	Func. settings:Measuring point ID		0 to 0	0
_:10621:137	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:139	Func. settings:Measuring point ID		0 to 0	0
_:10621:140	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:106	Func. settings:Measuring point ID		0 to 0	0
_:10621:107	Func. settings:Phasor 1		Freely editable text	
_:10621:108	Func. settings:Phasor 2		Freely editable text	
_:10621:109	Func. settings:Phasor 3		Freely editable text	
_:10621:111	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:112	Func. settings:Measuring point ID		0 to 0	0
_:10621:113	Func. settings:Phasor 1		Freely editable text	
_:10621:114	Func. settings:Phasor 2		Freely editable text	
_:10621:115	Func. settings:Phasor 3		Freely editable text	
_:10621:117	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:118	Func. settings:Measuring point ID		0 to 0	0
_:10621:119	Func. settings:Phasor 1		Freely editable text	
_:10621:120	Func. settings:Phasor 2		Freely editable text	
_:10621:121	Func. settings:Phasor 3		Freely editable text	
_:10621:123	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:124	Func. settings:Measuring point ID		0 to 0	0
_:10621:125	Func. settings:Phasor 1		Freely editable text	
_:10621:126	Func. settings:Phasor 2		Freely editable text	
_:10621:127	Func. settings:Phasor 3		Freely editable text	
_:10621:129	Func. settings:Phasor		Freely editable text	

9.5.10 Information List

No.	Information	Data Class (Type)	Type
General			
_:10621:52	Func. settings:Behavior	ENS	O
_:10621:53	Func. settings:Health	ENS	O

365