Addr.	Parameter	C	Setting Options	Default Setting
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check Double activat. blk.		• no • yes	yes
Disconnector				
_:5401:101	Disconnector:Maximum output time		0.01 s to 1800.00 s	10.00 s
_:5401:102	Disconnector:Dwell time		0.00 s to 60.00 s	0.00 s
_:5401:103	Disconnector:Switching device type		• switch-disconnector • disconnector • grounding switch • fast grounding switch	disconnector

8.2.3.5 Information List

No.	Information	Data Class (Type)	Type
Control			
_:4201:503	Control:>Sw. authority local	SPS	I
_:4201:504	Control:>Sw. authority remote	SPS	I
_:4201:505	Control:>Sw. mode interlocked	SPS	I
_:4201:506	Control:>Sw. mode non-interl.	SPS	I
_:4201:53	Control:Health	ENS	O
_:4201:58	Control:Cmd. with feedback	DPC	C
_:4201:302	Control:Switching auth. station	SPC	C
_:4201:308	Control:Enable sw. auth. 1	SPC	C
_:4201:309	Control:Enable sw. auth. 2	SPC	C
_:4201:310	Control:Enable sw. auth. 3	SPC	C
_:4201:311	Control:Enable sw. auth. 4	SPC	C
_:4201:312	Control:Enable sw. auth. 5	SPC	C
_:4201:313	Control:Switching authority	ENS	O
_:4201:314	Control:Switching mode	ENS	O
Interlocking			
_:4231:500	Interlocking:>Enable opening	SPS	I
_:4231:501	Interlocking:>Enable closing	SPS	I
_:4231:502	Interlocking:>Enable opening(fixed)	SPS	I
_:4231:503	Interlocking:>Enable closing (fixed)	SPS	I
_:4231:53	Interlocking:Health	ENS	O
Disconnector			
_:5401:500	Disconnector:>Acquisition blocking	SPS	I
_:5401:501	Disconnector:>Reset switch statist.	SPS	I
_:5401:53	Disconnector:Health	ENS	O
_:5401:58	Disconnector:Position	DPC	C
_:5401:300	Disconnector:Open command	SPS	O
_:5401:301	Disconnector:Close command	SPS	O
_:5401:302	Disconnector:Command active	SPS	O
_:5401:305	Disconnector:Op.ct.	INS	O

8.3 Control Functionality

8.3.1 Command Checks and Switchgear Interlocking Protection

Before switching commands can be issued by the SIPROTEC 5 device, several steps are used to check the commands:

- Switching mode (interlocked/non-interlocked)
- Switching authority (local/DIGSI/station/remote)
- Switching direction (set=actual)
- Bay interlocking and substation interlocking
- 1-out-of-n check (double-activation blocking)
- Blocking by protection function

Confirmation IDs

SIPROTEC 5 devices offer the ability to safeguard various operations with confirmation IDs. The following confirmation IDs from the Safety menu apply to the control functions:

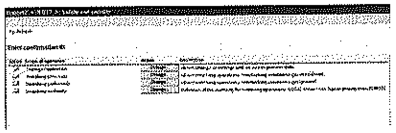

Figure 8-26 Confirmation IDs in DIGSI 5: Settings Menu

The following table identifies the meanings of the confirmation IDs:

Table 8-16 Relevant Confirmation IDs for Controls

Confirmation ID	Meaning	Description
Set/operate	Changing settings	The confirmation ID is requested before device parameters can be changed.
Control (process)	General release for control of switching devices	The confirmation ID is usually not needed for bay controllers. In the case of protection devices, this confirmation ID can be used to safeguard control of switching devices.
Control (non-interlocked)	Switching non-interlocked	Switching mode: Release for switching without querying the interlocking conditions (S1 operation). The fixed interlocking conditions (for example, >Enable opening (fixed) and >Enable closing (fixed)) are still queried if this is set in the parameters. The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.
Switching Authority	Release for switching authority Local	The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.

The confirmation IDs are preset with the following values:

- Set/operate 222222
- Control (process, interlocked) 333333
- Control (non-interlocked) 444444
- Switching authority local 666666

If you have configured a device with key switches, the confirmation IDs for non-interlocked switching and switching authority are not displayed or editable in DIGSI; the function is handled by the position of the key switch.

To increase security, change these codes with DIGSI.

Switching Mode (Interlocked/Non-Interlocked)

The switching mode determines whether or not the switchgear interlocking that has been configured in the CFC is checked before the command is output.

You can change the switching mode with the key switch S1 (interlocking off/normal). For devices without a key switch, you can change the switching mode with a corresponding menu item on the display (after entering a confirmation ID). You can also set the switching mode for switching commands from the sources DIGSI, station or remote.

DANGER

If the switching mode = non-interlocked, the switchgear interlocking protection is shut off

Erroneous switching operations can lead to severe or fatal injuries.

- Ensure manually that all checks have been implemented.

In addition, you can set the switching mode directly with a binary input or CFC. Use the **General** function block (see next figure).

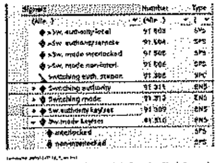

Figure 8-27 Switching Mode in Function Block General

The following table shows the effects of changing the switching mode to use command checks.

Table 8-17 Relationship Between Switching Mode and Command Checks

Command Check	Switching Mode	
	Interlocked	Non-Interlocked
Switching authority	Checked	Checked
Switching direction (set=actual)	Checked	Checked
Fixed interlocking conditions	Checked	Checked
Interlocking conditions	Checked	Not checked
1-out-of-n check (double-activation blocking)	Checked	Not checked
Blocking by protection function	Checked	Not checked

Switching Authority

The switching authority determines which command source is allowed. The following command sources are possible:

- Local:
  A switching command from the local control (cause-of-error source Local/auto) is possible only if the switching authority is set to Local and the device is capable of local operation. Setting the switching authority to Local is typically accomplished with key switch S5 (Local/Remote). In this case, commands from all other sources are rejected. If the switching authority is set to Local, the setting cannot be changed remotely.
- DIGSI:
  A switching command from DIGSI (connected via USB or Ethernet, cause-of-error source Maintenance) is accepted only if the switching authority in the device is set to Remote. Once DIGSI has signed on the device for command output, no commands from other command sources or a different DIGSI PC will be executed.
- Station:
  This switching authority level can be activated via a parameter in the General function block. A switching command from the station level (cause-of-error source Station or Automatic station) is accepted if the switching authority is set to Remote and the controllable Station switching authority is set. This is accomplished by a command from the substation automation technology. Switching commands from the device or from outside the station (cause-of-error source Local, Remote or Automatic remote) are rejected.
  Full support of the this switching authority level is assured only when using the IEC 61850 protocol.
- Remote:
  This switching authority level stands from remote control directly from the network control center or (if the switching authority level Station is not activated) generally for Remote control. The cause-of-error source is Automatic remote. Commands from this level are accepted if the switching authority is set to Remote and the controllable Station switching authority is not set. Switching commands from the device or from the station (cause-of-error source Local, Station or Automatic station) are rejected.

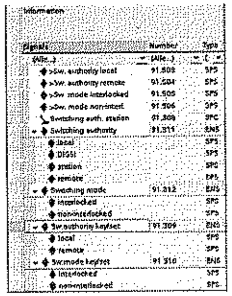

Figure 8-28 Display of Switching Authority and Switching Mode in Information Routing (in Function Block General)

Sw. authority key/set and Sw. mode key/set 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 8-18 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 8-28 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 8-29 and Figure 8-30)

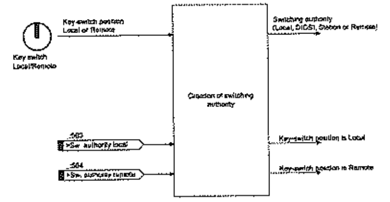

Figure 8-29 Establishing Switching Authority

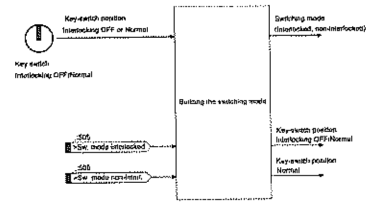

Figure 8-30 Establishing Switching Mode

In the case of both functions, the input signals overwrite 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).

Верно с оригинала

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 in 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 1052. By default, these are not used.

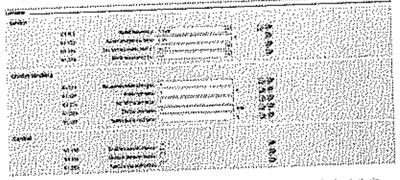

Figure 8-31 How to Activate the Station Switching Authority and to Enable Several Switching-Authority Levels

Table 8-19 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 8-20 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 extension of the switching-authority check. This makes it possible to differentiate the Remote command sources at the bay level. Switching authorities can be routed 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 8-33). In order to permit an additional command source to switch, you must activate this specific switching authority. In order to do this, set the controllable `Enable sw. auth. 1` to `Enable sw. auth. 5`.

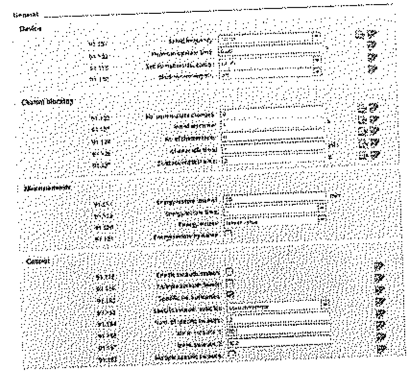

Figure 8-32 Activating Additional Options of the Switching Authority

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 8-21 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 8-22 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.

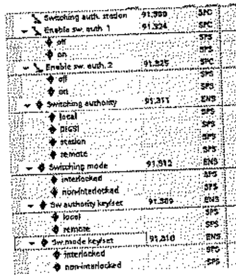

Figure 8-33 Display of Switching Authority and Switching Mode in the Information Routing (in Function Block General), Example of 2 Activated Remote Switching Authorities

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.

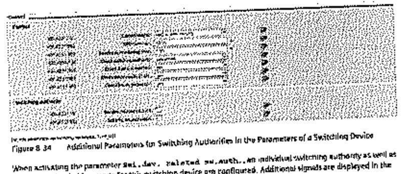

Figure 8-34 Additional Parameters for Switching Authorities in the Parameters of a Switching Device

When activating the parameter `Sw. 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 8-35 Expanded Parameters for the Switching Authority in the Switching Device

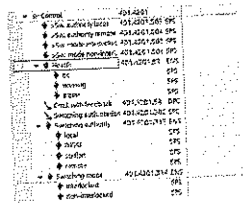

Figure 8-36 Individually Modifiable Switching Authority and Switching Mode for Switching Devices

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.

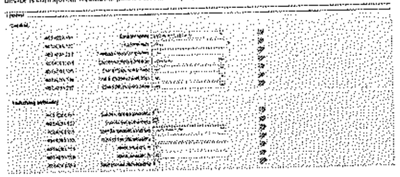

Figure 8-37 Parameters of the FB Control with all Additional Options

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. stat...	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 8-38 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.

Signals	Number	Type
(All)	(All)	
▾ Circuit breaker 1	201	
▸ Trip logic	201.5341	
▸ Circuit break.	201.4261	
▸ Manual close	201.6541	
▸ Control	201.4201	
▾ Interlocking	201.4231	
>Enable opening	201.4231.500	SPS
>Enable closing	201.4231.501	SPS
>Enable opening (fixed)	201.4231.502	SPS
>Enable closing (fixed)	201.4231.503	SPS
▸ Health	201.4231.53	ENS

Figure 8-39 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 equation is: 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.

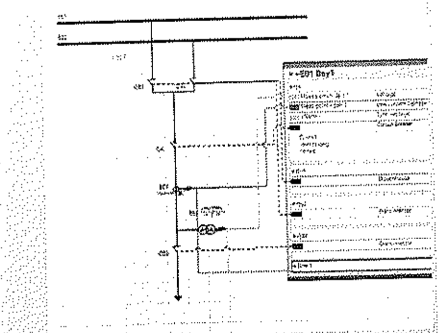

Figure 8-40 Feeder Bay for a Double Busbar System

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

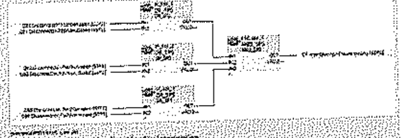

Figure 8-41 Interlocking Chart for Bay Interlocking

Since the Disconnector function block provides the defined positions On or 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 >Release on signal in the Interlocking function block in the Circuit breaker QA function group (see Figure 8-41).

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).

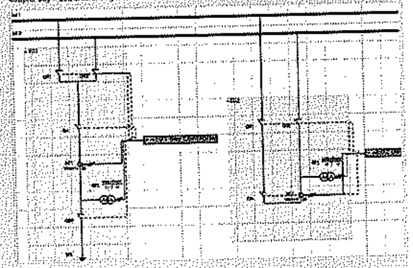

Figure 8-42 System with Feeder and Coupler Bays

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 in 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 store 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 the figure below).

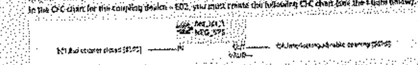

Figure 8-43 Interlocking Chart for Substation Interlocking

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).

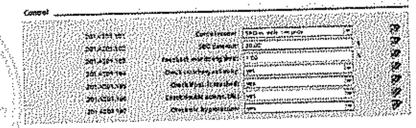

Figure 8-44 Activating the Double-Activation Blocking

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 in the switching device function groups (see figure below).

▾ Circuit breaker 1	201	
▸ Trip logic	201.5341	
▾ Circuit break.	201.4261	
>Ready	201.4261.500	SPS
>Acquisition blocking	201.4261.501	SPS
>Reset switch statist.	201.4261.502	SPS
>Reset AcqBlk&Subst	201.4261.504	SPS
▸ External health	201.4261.503	ENS
▸ Health	201.4261.53	ENS
▾ Position	201.4261.58	DPC
not selected		SPS
open		SPS
closed		SPS
intermediate position		SPS
disturbed position		SPS
acquisition blk. active		SPS
manual update active		SPS

Figure 8-45 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.

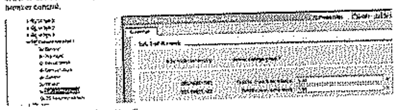

Figure 8-46 Command Execution

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.

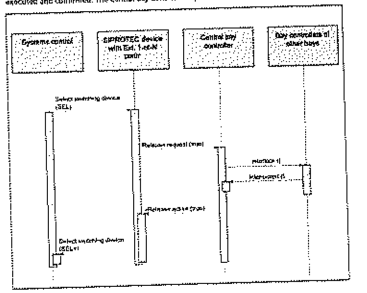

Figure 8-47 Setting the Blocking

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 OAT (see the following figure) only when interlocking termination has been acknowledged positively via the input >Release active.

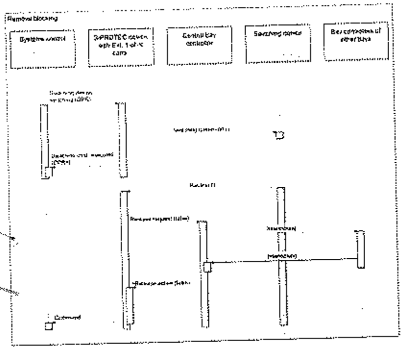

Figure 8-48 Terminating the Blocking

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 set, this switching device is blocked for additional switching operations.	true/false

Blocking by Protection Function

- Default setting (_:107) 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.

This applies to automatic reclosing as well. Switching commands must be prevented as long as automatic reclosing is active.

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 circuit-breaker interlocking (see Figure 8-44).

NOTE

Remember: for instance, just 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 and automatic reclosing 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 Line)
- Circuit-breaker failure protection: Pickup (Circuit-breaker failure protection)
- General: In progress (Automatic reclosing function)

8.3.2 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 – Selected, OPR – Operate, CMT – Command execution end, SPN – Spontaneous)
- Status or switching direction

EXAMPLE

The following example illustrates control of a disconnector (QB1) 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

Figure 8-49 to Figure 8-55 indicates command logging for various scenarios of the standard control model SBO with feedback monitoring.

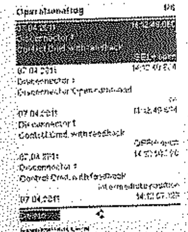

Figure 8-49 Positive Case (Display 1)

Figure 8-50 Positive Case (Display 2)

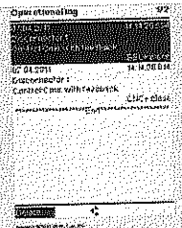

Figure 8-51 Positive Case with Command Cancellation

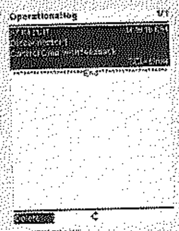

Figure 8-52 Negative Case (Blocked by Switchgear Interlocking)

Figure 8-53 Negative Case (Expiration of Feedback Supervision Time) (Display 1)

Figure 8-54 Negative Case (Expiration of Feedback Supervision Time) (Display 2)

ВЯРНО С ОРИГИНАЛА

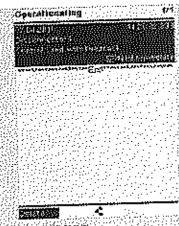

Figure 8-55 Spontaneous Status Change

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 8-23 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

8.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Control				
_: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

Addr.	Parameter	C	Setting Options	Default Setting
_:106	Control:Check double activat. blk.		• no • yes	yes
_:107	Control:Check blk. by protection		• no • yes	yes

8.3.4 Information List

No.	Information	Data Class (Type)	Type
Control2			
_:53	Control:Health	ENS	O
_:58	Control:Cmd. with feedback	DPC	C

8.4 Synchronization Function

8.4.1 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 line/busbar

8.4.2 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 delta-f 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.

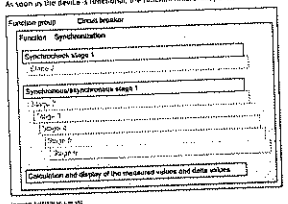

Figure 8-56 Structure/Embedding of the Function

8.4.3 Connection and Definition

Connection

You can find examples for the synchronization of line and busbar in the following 2 figures. Figure 8-59 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 8-57 and Figure 8-58):
  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 8-58):
  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.

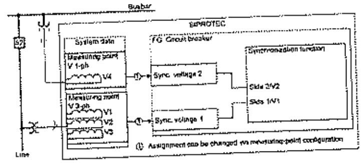

Figure 8-57 Synchronization of Line and Busbar, Connection via 4 Voltage Inputs

[1] Do not confuse the designations V1 and V2 with the numbering of the voltage inputs V1 to V4 (Figure 8-57) and V1 to V8 (Figure 8-58).

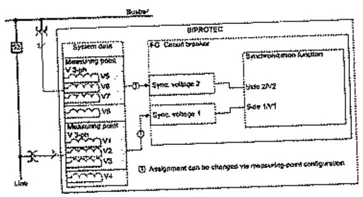

Figure 8-58 Synchronization of Line and Busbar, Connection via 6 Voltage Inputs

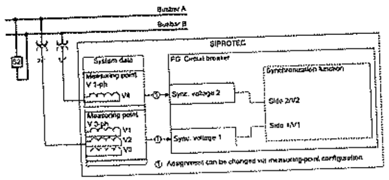

Figure 8-59 Synchronization of 2 Busbars via Cross-Coupling, Connection via 4 Voltage Inputs

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 = 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 8-57 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 8-60 shows the circumstances. The phase angle α1 was added to the zero axis as a 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 8-60, the direction of rotation is counterclockwise (mathematically positive). At f2 < f1, the direction of rotation is clockwise.

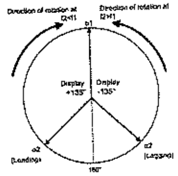

Figure 8-60 Phase-Angle Difference Representation dα

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.

8.4.4 General Functionality

Overview of a Synchronization Stage (Sync Stage)

A synchronization stage can be integrated in the following blocks (see Figure 8-61):

- 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 8.4.6 Sequence of Functions)

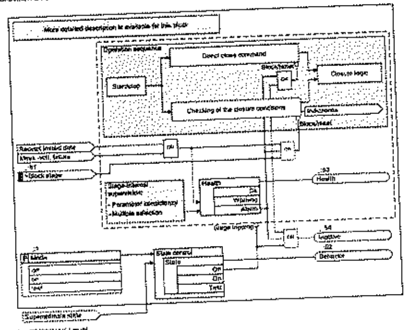

Figure 8-61 Overview of the Stage Logic

Stage Control

The normal stage control is used for a synchronization stage (see Figure 8-61).

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.

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Operating Range

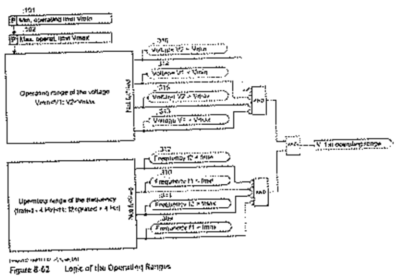

Figure 8-62 Logic of the Operating Ranges

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
  Definite 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 commands of the synchronization stage are no longer tested. In other words, a release of the closure 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 8-24 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.

The parameter is defined as -dα = -(α2 - α1).

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

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

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.

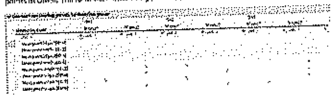

Figure 8-63 Connecting the Measuring Points with the Circuit-Breaker Function Group

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 VN.
- 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.

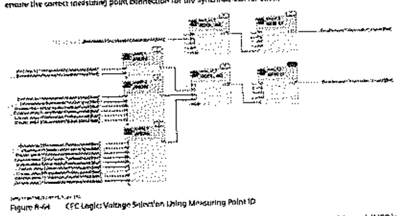

Figure 8-64 CFC Logic: Voltage Selection Using Measuring Point ID

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.

8.4.6 Sequence of Functions

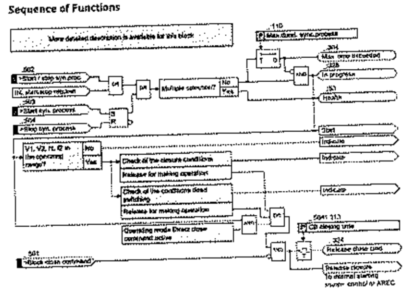

Figure 8-65 Sequence of Functions

Start

The synchronization stage must be started to check the closing conditions. The synchronization stage can be started device-internally by the controller and the reclosing, or externally, via binary input signals, for example by an external automatic reclosing (AREC). (see section 8.4.12 Interaction with Control, Automatic Reclosing (AREC), and External Triggering).

At the start, the system checks whether there is a multiple selection by the synchronization stage (see section Monitoring in chapter 8.4.4 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 8.4.4 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 8.4.9 Closing Conditions for the Synchronous/Asynchronous Stage Type to 8.4.11 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. conditio. OK. The 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 8.4.7 Closing Conditions for the Synchrocheck Stage Type and 8.4.8 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 internal start, the controller or the AREC 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 8.4.10 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 make 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 8.4.11 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 or AREC, 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.

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8.4.7 Closing Conditions for the Synchrocheck Stage Type

Checking Closing Conditions

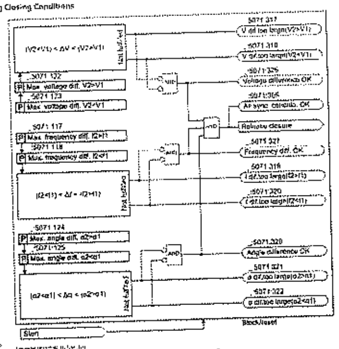

Figure 8-66 Closing Conditions for the Synchrocheck Function

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. conditions 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 8.4.6 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 dif. 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) Limit dfdiff/dt for sync. op parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter (_:141) Max. value dfdiff/dt syn) is exceeded, the indication (_:329) d fdiff/dt too large is issued.

8.4.8 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 (Δf ≈ 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

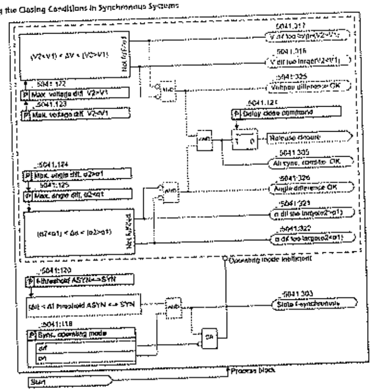

Figure 8-67 Closing Conditions when Switching Synchronous Systems

The frequency difference is very low in the synchronous systems operating mode. It is below the threshold value f-threshold ASYN<->SYN. The status is signaled via the State f-synchronous indication. Only the parameters ΔV and Δα are checked for issuing an activation release (see Figure 8-66). 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 8.4.7 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 dif. 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 (_:329) d fdiff/dt too large is generated.

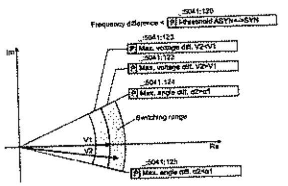

Figure 8-68 Connecting Under Synchronous System Conditions

Checking Closing Conditions in Asynchronous Systems

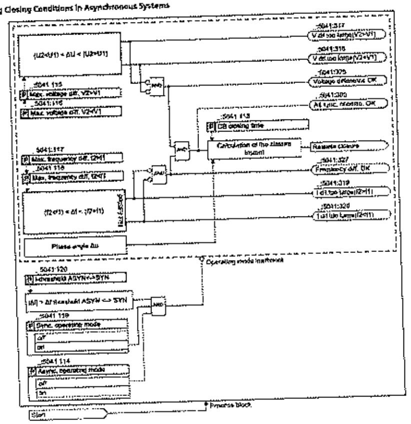

Figure 8-69 Closing Conditions when Switching Asynchronous Systems

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 Δα 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 (ΔV = 0, Δα = 0).

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

Figure 8-70 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.

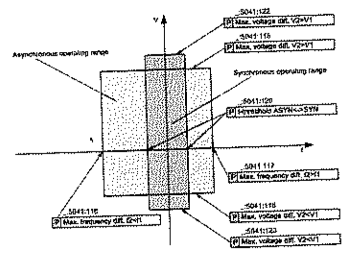

Figure 8-70 Operating Range Under Synchronous and Asynchronous Conditions for Voltage (V) and Frequency (f)

8.4.9 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 those 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. freq. 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.

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- 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 0.8 Hz to 1.6 Hz are detected and smoothed. This stabilizes the release checks in the presence of frequently changing conditions 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.

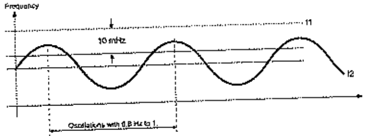


Figure 8-71 Example: Frequency Difference between the Constant Frequency f1 and the Sinusoidal Oscillating Frequency f2

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. "f threshold" parameter makes it possible to limit the increase in instantaneous frequency value in relation to the respective frequency threshold value.

8.4.10 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 8.4.4 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 that the parts V_1 and V_2 are de-energized

Each of these conditions can be made effective individually via parameters 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.

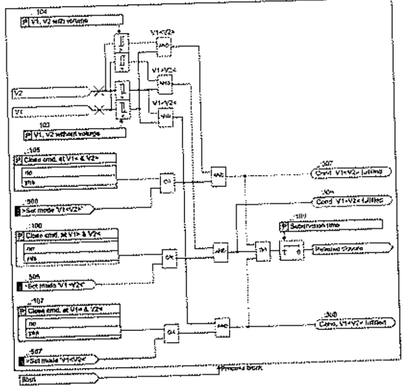


Figure 8-72 Release Conditions for Switching to De-Energized Line/Busbar

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.

8.4.11 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 8-73).

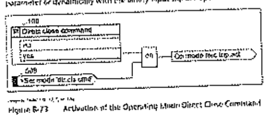


Figure 8-73 Activation of the Operating Mode Direct Close Command

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 8.4.4 General Functionality).

8.4.12 Interaction with Control, Automatic Reclosing (AREC), 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 linked to 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 8.4.6 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 and synchronization function.

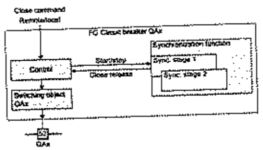


Figure 8-74 Interaction of the Control with the Synchronization Function

With Automatic Reclosing

The automatic reclosing mechanism (AREC) can also work with the synchronization function. Both functions are always located in a function group Circuit breaker. Consequently the AREC and synchronization function always work with the circuit breaker that is linked to the function group Circuit breaker.

You must select a synchronization stage via settings within the AREC so that closure is synchronized by the AREC. The tests for the synchronization stage are used for the closure by the AREC. If no synchronization stage is selected, the AREC then activates without synchronization.

If closure is to be synchronized via the AREC, the AREC automatically generates an internal signal which starts the synchronization function. The functional sequence is described in chapter 8.4.6 Sequence of Functions. After fulfilling all closing conditions, the synchronization sends a release signal to the AREC, which closes the circuit breaker and then stops and synchronization function.

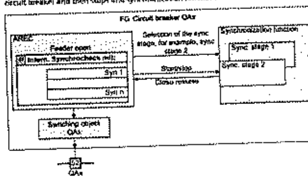


Figure 8-75 Connection of the AREC to the Synchronization Function

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 syn. process and >Stop syn. process
- State-controlled, via the signal >Start / stop syn.proc. (see also chapter 8.4.6 Sequence of Functions).

The start is followed by the functional sequence (see chapter 8.4.6 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.

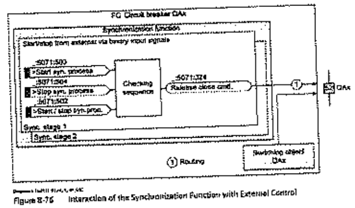


Figure 8-76 Interaction of the Synchronization Function with External Control

8.4.13 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 to issue, for example, an additional release during an automatic reclosing or a 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

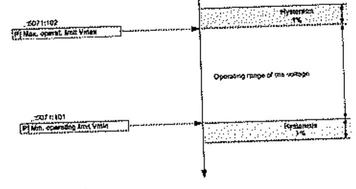
The voltages V1 and V2 are established via the connection of the measuring points to the interface of the function groups (refer to chapter 8.4.3 Connection and Definition). The measuring point connected to the interface Voltage is the reference side 1 with the reference voltage V1. The measuring point 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 8.4.3 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:

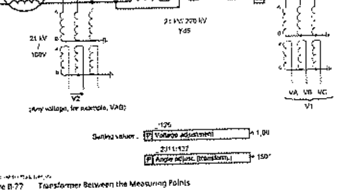


Figure 8-77 Transformer Between the Measuring Points

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 8-77 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 8-77), 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 rotation angle with 360°. A transformer with vector group 5 yields an angular adjustment of 360° - (5 · 30°) = 210°.

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 (_:5041:113) 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 11.12 Primary and Secondary Testing of the Synchronization Function).

This parameter only occurs for the stage type Synchronous/asynchronous

8.4.14 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
- Default setting (_:5071:118) Max. frequency diff. f2<f1 = 0.20 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.

8.4.15 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 combination 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 this 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).
off	off	Both operating modes are deactivated. No closing release can be therefore be [illegible] with 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.

8.4.16 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 as no for reasons of safety. Set the operating mode only dynamically via the assigned binary input signal (for example >Operating mode "V1>V2<") (see also figure 8-77). This prevents one of these operating 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 starting 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 8-74). This prevents this operating mode from being incorrectly activated statically thereby resulting in an incorrect switching.

8.4.17 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
_:5071:108	Synchrocheck 1:Direct close command		• no • yes	no
_:5071:126	Synchrocheck 1:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized 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./Asycr.1:Mode		• off • on • test	off
_:5041:101	Sychr./Asycr.1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5041:102	Sychr./Asycr.1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5041:110	Sychr./Asycr.1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5041:108	Sychr./Asycr.1:Direct close command		• no • yes	no
_:5041:126	Sychr./Asycr.1:Voltage adjustment		0.500 to 2.000	1.000
De-en.gized switch.				
_:5041:105	Sychr./Asycr.1:Close cmd. at V1< & V2>		• no • yes	no
_:5041:106	Sychr./Asycr.1:Close cmd. at V1> & V2<		• no • yes	no
_:5041:107	Sychr./Asycr.1:Close cmd. at V1< & V2<		• no • yes	no
_:5041:103	Sychr./Asycr.1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5041:104	Sychr./Asycr.1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5041:109	Sychr./Asycr.1:Supervision time		0.00 s to 60.00 s	0.1 s
Asynchr. op. mode				
_:5041:114	Sychr./Asycr.1:Async. operating mode		• off • on	on
_:5041:113	Sychr./Asycr.1:CB make time		0.01 s to 0.60 s	0.06 s

Addr.	Parameter	C	Setting Options	Default Setting
_:5041:115	Sychr./Asycr.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:116	Sychr./Asycr.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:117	Sychr./Asycr.1:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:5041:118	Sychr./Asycr.1:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
Synchr. op mode				
_:5041:119	Sychr./Asycr.1:Sync. operating mode		• off • on	on
_:5041:120	Sychr./Asycr.1:f-threshold ASYN<->SYN		0.010 Hz to 0.200 Hz	
_:5041:122	Sychr./Asycr.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	
_:5041:123	Sychr./Asycr.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:124	Sychr./Asycr.1:Max. angle diff. α2>α1		0° to 90°	10°
_:5041:125	Sychr./Asycr.1:Max. angle diff. α2<α1		0° to 90°	10°
_:5041:121	Sychr./Asycr.1:Delay close command		0.00 s to 60.00 s	0.00 s
df/dt limitation				
_:140	Adv. options:Limit df/dt for sync. op		• 0 • 1	false
_:141	Adv. options:Max. value df/dt syn		0.010 Hz/s to 0.025 Hz/s	0.019 Hz/s
_:142	Adv. options:Limit df/dt for asyn. op		• 0 • 1	false
_:143	Adv. options:Max. value df/dt 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 0.100 Hz	0.000 Hz

8.4.18 Information List

No.	Information	Data Class (Type)	Type
Measurements			
_:2311:303	General:Multiple selection	SPS	O
_:2311:304	General:Blocked no V selected	SPS	O
_:2311:329	General:V1	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

No.	Information	Data Class (Type)	Type
_:2311:301	General:df	MV	O
_:2311:302	General:dα	MV	O
Synchrocheck 1			
_:5071:81	Synchrocheck 1:>Block stage	SPS	I
_:5071:500	Synchrocheck 1:>Selection	SPS	I
_:5071:502	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
_:5071:501	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
_:5071:305	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 dif.too large(V2>V1)	SPS	O
_:5071:318	Synchrocheck 1:V dif.too large(V2<V1)	SPS	O
_:5071:319	Synchrocheck 1:f dif.too large(f2>f1)	SPS	O
_:5071:320	Synchrocheck 1:f dif.too large(f2<f1)	SPS	O
_:5071:321	Synchrocheck 1:α dif.too large(α2>α1)	SPS	O
_:5071:322	Synchrocheck 1:α dif.too large(α2<α1)	SPS	O
_:5071:304	Synchrocheck 1:Max. time exceeded	SPS	O
_:5071:323	Synchrocheck 1:Setting error	SPS	O
Synchr./Asyncr. 1			
_:5041:81	Sychr./Asycr.1:>Block stage	SPS	I
_:5041:500	Sychr./Asycr.1:>Selection	SPS	I
_:5041:502	Sychr./Asycr.1:>Start / stop syn.proc.	SPS	I
_:5041:503	Sychr./Asycr.1:>Start syn. process	SPS	I

No.	Information	Data Class (Type)	Type
_:5041:504	Sychr./Asycr.1:>Stop syn. process	SPS	I
_:5041:506	Sychr./Asycr.1:>Op. mode 'V1>V2<'	SPS	I
_:5041:505	Sychr./Asycr.1:>Op. mode 'V1<V2>'	SPS	I
_:5041:507	Sychr./Asycr.1:>Op. mode 'V1<V2<'	SPS	I
_:5041:508	Sychr./Asycr.1:>Op. mode 'dir.ch.cmd'	SPS	I
_:5041:501	Sychr./Asycr.1:>Block close command	SPS	I
_:5041:54	Sychr./Asycr.1:Inactive	SPS	O
_:5041:52	Sychr./Asycr.1:Behavior	ENS	O
_:5041:53	Sychr./Asycr.1:Health	ENS	O
_:5041:328	Sychr./Asycr.1:In progress	SPS	O
_:5041:324	Sychr./Asycr.1:Release close cmd.	SPS	O
_:5041:305	Sychr./Asycr.1:All sync. conditio. OK	SPS	O
_:5041:303	Sychr./Asycr.1:State f-synchronous	SPS	O
_:5041:325	Sychr./Asycr.1:Voltage difference OK	SPS	O
_:5041:326	Sychr./Asycr.1:Angle difference OK	SPS	O
_:5041:327	Sychr./Asycr.1:Frequency diff. OK	SPS	O
_:5041:307	Sychr./Asycr.1:Cond. V1>V2< fulfilled	SPS	O
_:5041:306	Sychr./Asycr.1:Cond. V1<V2> fulfilled	SPS	O
_:5041:308	Sychr./Asycr.1:Cond. V1<V2< fulfilled	SPS	O
_:5041:309	Sychr./Asycr.1:Frequency f1 > fmax	SPS	O
_:5041:310	Sychr./Asycr.1:Frequency f1 < fmin	SPS	O
_:5041:311	Sychr./Asycr.1:Frequency f2 > fmax	SPS	O
_:5041:312	Sychr./Asycr.1:Frequency f2 < fmin	SPS	O
_:5041:313	Sychr./Asycr.1:Voltage V1 > Vmax	SPS	O
_:5041:314	Sychr./Asycr.1:Voltage V1 < Vmin	SPS	O
_:5041:315	Sychr./Asycr.1:Voltage V2 > Vmax	SPS	O
_:5041:316	Sychr./Asycr.1:Voltage V2 < Vmin	SPS	O
_:5041:317	Sychr./Asycr.1:V dif.too large(V2>V1)	SPS	O
_:5041:318	Sychr./Asycr.1:V dif.too large(V2<V1)	SPS	O
_:5041:319	Sychr./Asycr.1:f dif.too large(f2>f1)	SPS	O
_:5041:320	Sychr./Asycr.1:f dif.too large(f2<f1)	SPS	O
_:5041:321	Sychr./Asycr.1:α dif.too large(α2>α1)	SPS	O
_:5041:322	Sychr./Asycr.1:α dif.too large(α2<α1)	SPS	O
_:5041:304	Sychr./Asycr.1:Max. time exceeded	SPS	O
_:5041:323	Sychr./Asycr.1:Setting error	SPS	O

8.4.19 External Synchronization

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

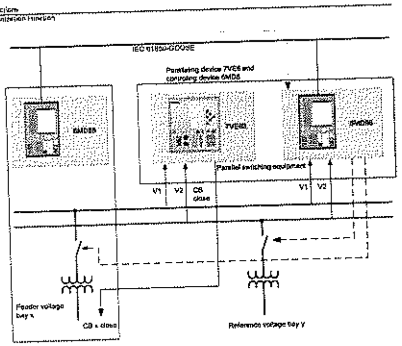


Figure 8-78 Triggering an External Synchronization Device

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.

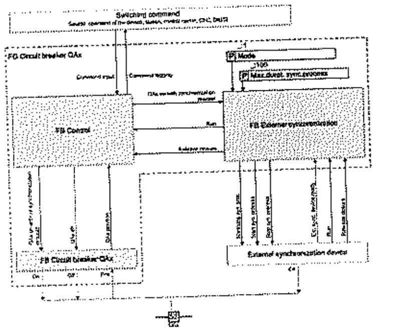


Figure 8-79 Interaction between Control and External Synchronization

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.

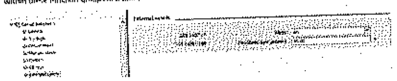


Figure 8-80 Instantiating the External Synchronization Function Block in the Circuit-Breaker Function Group

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 (_:4201:103) 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.

8.4.20 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 [illegible] External synchronization function block sends a command to cancel closing to the external synchronization device.

8.4.21 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

8.4.22 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. unr.	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

8.5 Switching Sequences

8.5.1 Overview of Functions

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

8.5.2 Function Description

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

- User-defined functions
  - User-defined function
  - User-defined function group
  - User-defined function block
  - User-defined function block [control]
  - Chart setting Bool
  - Chart setting Real
  - Chart setting Integer
  - Puls.met.val.
  - Swi. seq.

Figure 8-81 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 8-82). 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.

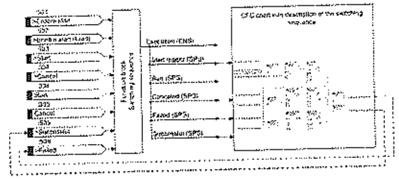


Figure 8-82 Switching Sequence Function Block

Starting and Canceling 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 cancelation 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 the current status will be displayed (see Figure 8-83, example with 2 switching sequences). You can start or cancel the switching sequences from this menu.

Figure 8-83
Overview of the Switching Sequences on the Device Display

8.5.3 Application and Setting Notes

This function block offers similar settings as the Control function block of a circuit breaker or disconnector (see chapter 8.2.1 General Overview).

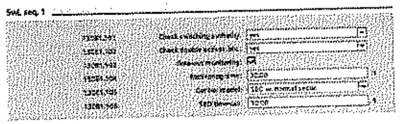


Figure 8-84 Settings of the Switching Sequence Function Block

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 commands 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:

Swi. seq. 1	13081	
>Enable start	13081.501	SPS
>Enable start (fixed)	13081.502	SPS
>Start	13081.503	SPS
>Cancel	13081.504	SPS
>Successful	13081.505	SPS
>Failed	13081.506	SPS
Health	13081.53	ENS
Execution	13081.302	ENS
start trigger		SPS
running		SPS
canceled		SPS
failed		SPS
successful		SPS
Start	13081.304	SPC
Cancel	13081.305	SPC
Switching auth. station	13081.303	SPC

Figure 8-85 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. Not in effect in the non-interlocked switching mode.
- *>Enable start (fixed)*: Non-removable interlocking conditions 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 Trigger* is 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.

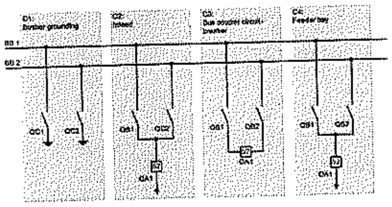


Figure 8-86 Example of a Substation

The switching sequence **C4 Off** (Figure 8-87) should switch off feeder bay C4. The circuit breaker is opened; followed by opening of one of the 2 busbar disconnectors.

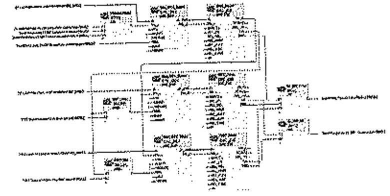


Figure 8-87 CFC Switching Sequence **C4 Off**

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Command Execution

As described in section Starting and Canceling a Switching Sequence, Page 1107, the display page of 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 status 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 (BSL_...). 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 PT 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 breakers 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 canceled signal 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.

8.5.4 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		0.02 s to 3600.00 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. #:Sw.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

8.5.5 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

8.6 User-Defined Function Block [Control]

8.6.1 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.

8.6.2 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 blocks on the top level (in parallel 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, INT) in the function block and route the corresponding indications (see following figure).

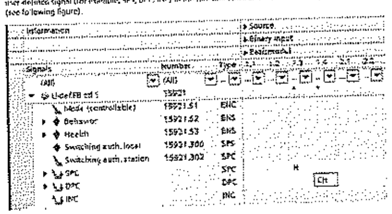

Figure 8-88 Information Routing with Inserted User-Defined Function Block [Control]: Process Indications and Some Individual Indications

8.6.3 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.

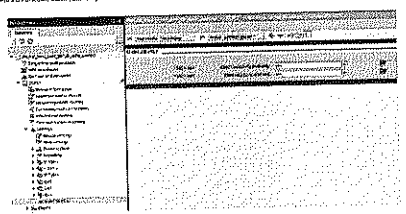

Figure 8-89 Parameterization Options of the User-Defined Function Block [Control]

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 8.3.1 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.

8.6.4 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

8.6.5 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
_:307	U-def.FB ctl.#:Switching auth. station	SPC	C

8.7 CFC-Chart Settings

8.7.1 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).

8.7.2 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 the function block and change the parameter value in the DIGSI information routing matrix to suit your specific application.

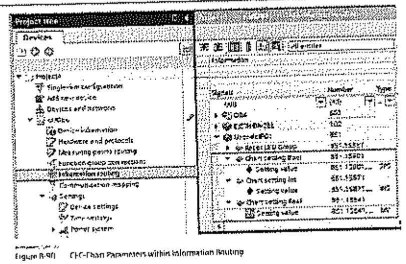

Figure 8-90 CFC-Chart Parameters within Information Routing

8.7.3 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.

8.7.4 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 %

8.7.5 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

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8.8 Transformer Tap Changers

8.8.1 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 (_:301) End higher pos.reached or (_:302) 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).

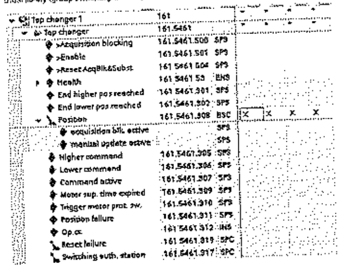

Figure 8-91 Tap Changer Functionality in the DIGSI Information Matrix

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 8.8.2 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.

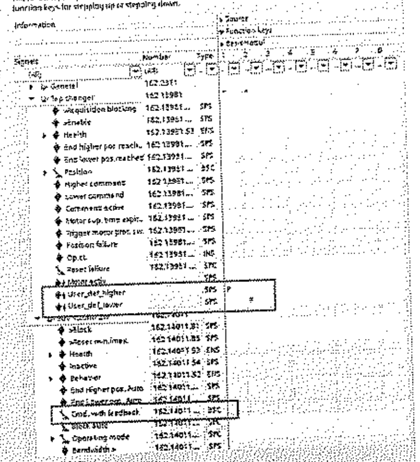

Figure 8-92 Routing of the Function Keys and CFC Signals

To use the function keys, you create 2 user-defined single-point indications (SPS). These are used for the function keys (for example, <F1>, Higher function key and <F2>, 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_DIR block:

- 1 means step up
- 0 means step down

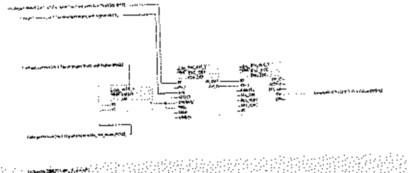

Figure 8-93 CFC Chart

Using this simple CFC chart, pressing the function keys to step up or down incrementally 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 received within the parameterized time Motor supervision time, the error message Position failure is issued.

The following position errors of the tap changer considered doing 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 of 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 controllable.

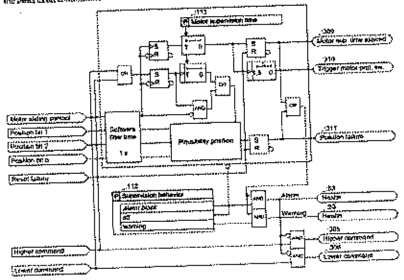

Figure 8-94 Position and Motor Supervision Logic

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 failure (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.

8.8.2 Application and Setting Notes

Parameters of the Transformer Tap Changer Function Group

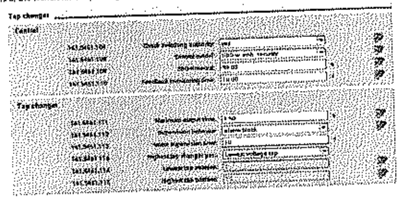

Figure 8-95 Parameters of the Tap Changer

> **NOTE**
>
> If run positions, this means internal tap-changer positions without voltage changes, are available, 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 1119 . 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.

52[illegible]

Details:

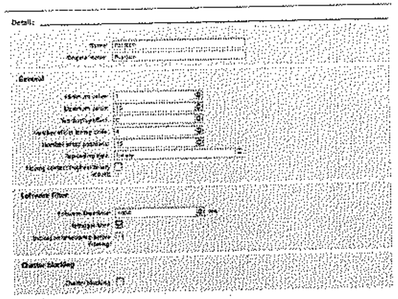

Figure 8-96 Properties Dialog

Parameter: Minimum value

- Default setting Minimum value = 1

Parameter: Maximum value

- Default setting Maximum value = 15

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 = 4

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 3 bits for 7 binary-encoded transformer taps. The range of values extends from 2 to 32.

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 1125.

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 3 to 6, BI4 is the moving contact. The encoding is in binary.

Table 8-25 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 = 3	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 3. 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:	2
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 8-26 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 = 1	1	0	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.

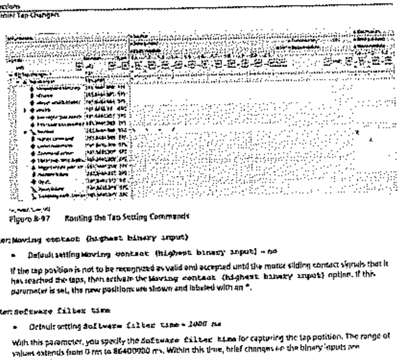

Figure 8-97 Routing the Tap Setting Commands

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.

8.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Tap changer				
_:101	Tap changer:Check switching authority		• no • yes	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	1.50 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

8.8.4 Information List

No.	Information	Data Class (Type)	Type
Tap changer			
_:500	Tap changer:>Acquisition blocking	SPS	I
_:501	Tap changer:>Enable	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
_:308	Tap changer:Position	BSC	C
_:305	Tap changer:Higher command	SPS	O
_:306	Tap changer:Lower command	SPS	O
_:307	Tap changer:Command active	SPS	O
_:309	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
_:319	Tap changer:Reset failure	SPC	C

8.9 Voltage Controller

8.9.1 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 and 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.

8.9.2 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.

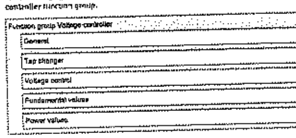

Figure 8-98 Structure/Embedding of the Function Group

The functions General (GAPC), Tap changer (YLTC), and Voltage controller (ATCC) are logical node points 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 8-99 shows these interfaces in a block structure.

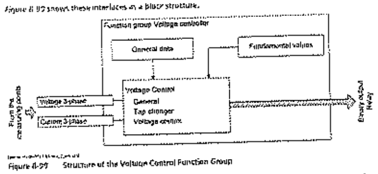

Figure 8-99 Structure of the Voltage Control Function Group

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

8.9.3 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.

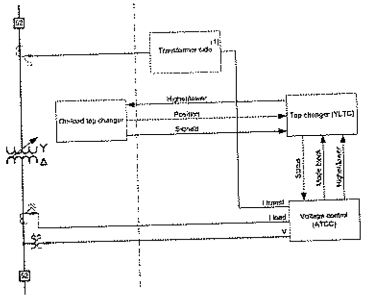

Figure 8-100 Voltage-Controller Constellation for Two-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

(1) Only if a transformer side is present

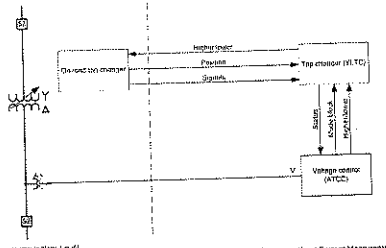

Figure 8-101 Voltage-Controller Constellation for Two-Winding Transformers without Current Measurement

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 transformers 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 or 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.

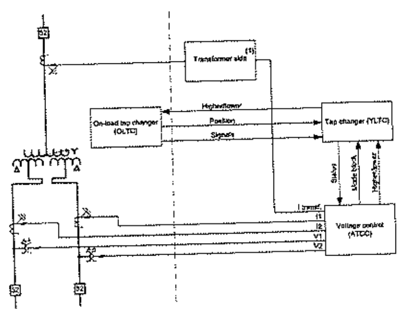

Figure 8-102 Voltage-Controller Constellation for Three-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

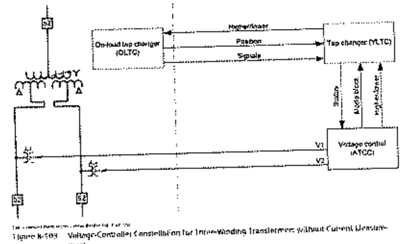

Figure 8-103 Voltage-Controller Constellation for Three-Winding Transformers without Current Measurement

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 set. 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.

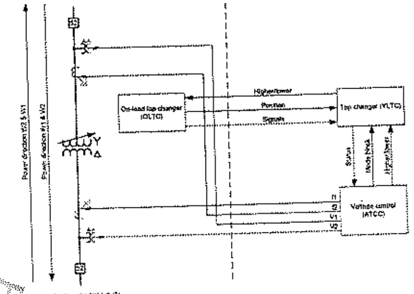

Figure 8-104 Voltage Controller Constellation for Grid Coupling Transformers

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 8.9.4 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 voltage`, 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 in 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` = `WithMaxLoad`).

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 superv.* indication appears and the function switches to the alarm state.

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Logic of the Function

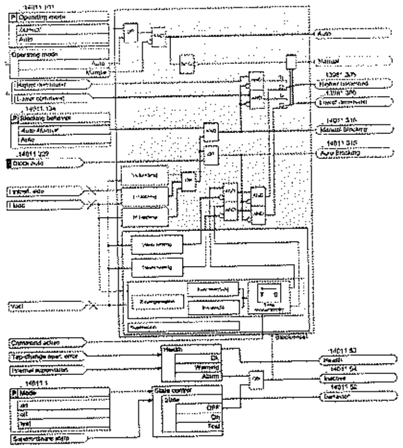

Figure 8-105 Higher-Level Logic of the Voltage Controller

(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 3.10.2 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 lower limit of the bandwidth.

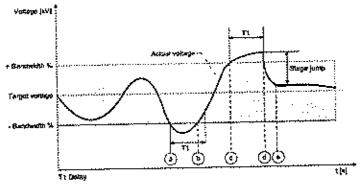

Figure 8-106 Actual Voltage Curve during Control Deviation

(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 band width, 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 8.9.4 Application and Setting Notes, margin title 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.

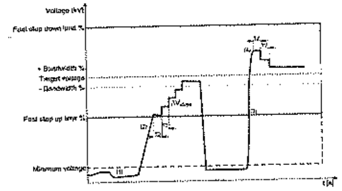

Figure 8-107 Actual Voltage Curve during Control with T2

(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

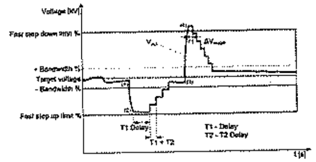

Figure 8-108 Actual Voltage Curve During Larger Control Deviations

(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 8-108 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 (_:14011:306) Fast Step Down active and (_:14011:307) Fast Step Up active.

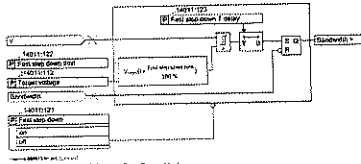

Figure 8-109 Logic of the Fast Step Down Mode

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.

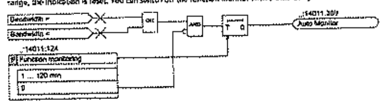

Figure 8-110 Logic of the Function Supervision for Automatic Operation

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 cos φ 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 8.9.4 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.

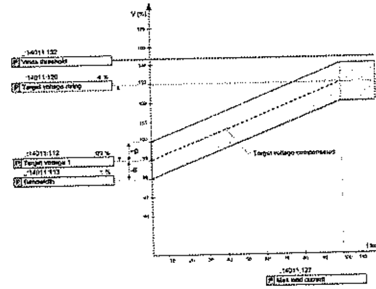

Figure 8-111 Control Characteristic with Z Compensation

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.

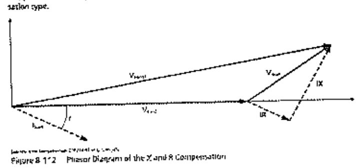

Figure 8-112 Phasor Diagram of the X and R Compensation

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

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V_{LoadP}	Voltage of load point (target voltage, $V_{Load} = V_{Act} - V_{drop}$)
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 LIBlock 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 calculated.

By assigning the tap changer to the transformer side, you also arrange 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.

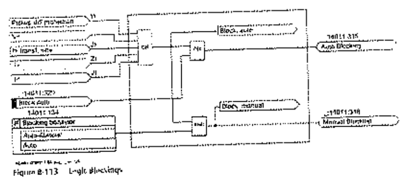

Figure 8-113 Logic Blockings

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

If the tap changer is assigned to the transformer side, is 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 (reference 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 8-27 and Table 8-28 show the total scope in case a 3-phase voltage measuring point is also connected

Table 8-27 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 8-28 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

8.9.4 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 8.8.2 Application and Setting Notes.

For the tap changer inside the voltage controller, the parameters for the control model are copies of those 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 Without load 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, reservation is known as Select Before Operate (SBO)

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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 (_:14011:160) 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 _:15601:17[illegible] while the address is _:16351:17[illegible] 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 (_:15601:146) 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 (_:16351:146) 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, no 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:

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

$V_{rated\,sec}$	Secondary rated voltage of the transformer
$V_{tap\,N}$	Primary tap voltage of the transformer of tap N
$V_{(N-1)prim}$	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:

$$T_{1\_delay} = \frac{T_1 \cdot B}{|D|}$$

T_1 – Parameter T1 delay

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

D = Control deviation

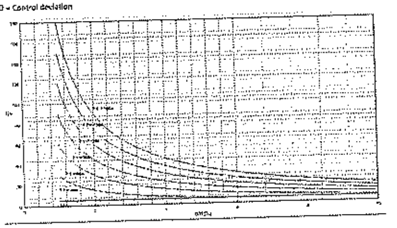

Figure 8-114 Inverse Control Characteristic

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 or 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 T1 control table to On.

For the three-winding transformer, the address of the Regulate with T2 at start parameter is _:15601:163 while the address is _:16351:163 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 (_:120) 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 (_:124) 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 (_:14011:125) 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-XandR.

Consider the following parameter 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_{Line} [%] if I_{Load} = 100 %

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

$V_{SetComp}$	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 at 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-XandR :

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-XandR. 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:

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

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 Transformers and Grid Coupling Transformers

Parameter: Line drop compensation

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- 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-X and R:

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 = 1

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 rise 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

8.9.5 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-X and R	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		3 % 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
_:15601:146	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

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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-pos.lim 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: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

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	off
_: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	100.000 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

8.9.6 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:>Invalid	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

No.	Information	Data Class (Type)	Type
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Op.ct.	INS	O
_:13981:319	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 SCORECARD	C
_:14011:329	90V V.contr.2w:Block auto	SPC	C
_:14011:312	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

No.	Information	Data Class (Type)	Type
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 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:Op.ct.	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.max.	SPS	I
_:15601:53	90V V.contr.3w:Health	ENS	O
_:15601:54	90V V.contr.3w:Inactive	SPS	O
_:15601:52	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:V act.	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 tar.w1	MV	O
_:15601:330	90V V.contr.3w:V tar.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:>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 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:Op.ct.	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.max.	SPS	I
_:16351:53	90V V.contr.gc:Health	ENS	O
_:16351:54	90V V.contr.gc:Inactive	SPS	O
_:16351:52	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	I
_: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:V 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 tar.w1	MV	O
_:16351:330	90V V.contr.gc:V tar.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		

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

9 Supervision Functions

ВЯРНО С ОРИГИНАЛА

9.1 Overview

SIPROTEC 5 devices are equipped with an extensive and integrated supervision concept. Continuous supervision:

- Ensures the availability of the technology used
- Avoids subfunction and overfunction 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.

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9.2 Resource-Consumption Supervision

9.2.1 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. It is determined that an application created is likely to overload the device. DIGSI 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 settings sheet. The following figure shows an example of the view of the load model in DIGSI 5:

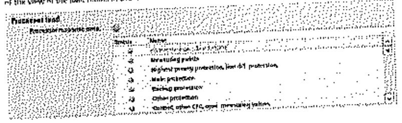

Figure 9-1 Visualization of the Load Model in DIGSI

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 9-1) 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 invoke interlockings 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 preprocessing for insertable functions (for example, Line function group and Circuit-breaker function group)

Functional Area	Brief Description	Change in Load
• 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
Protection Communication	Signal transmission via protection communication and differential protection communication	Adding or removing • Communication modules for the protection interface (in the DIGSI 5 Hardware and Protocols view) • Routings to the protection interface
Function Groups	Function Groups	Adding or removing function groups such as: • FG VI 3-phase
Overcurrent protection	Overcurrent protection	Adding or removing • Overcurrent protection, phases • Overcurrent protection, ground
Measuring point supervising functions, protection communication	• Measuring-point supervision functions • Scope of the data transmitter via the protection communication	Adding or removing measuring points or individual supervising functions, such as • 3-phase current measuring point • 3-phase voltage measuring point • Measuring-voltage failure detection Add or remove from transmission values via the protection communication • Single-point indications • Measured values
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 events • 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 to 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.

9.2.2 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.

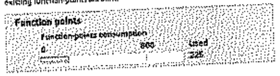

Figure 9-2 Resource Overview: Function-Points Consumption

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.

9.2.3 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 a realistic 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.

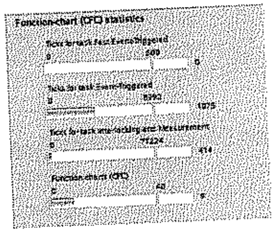

Figure 9-3 CFC Statistics

> **NOTE**
>
> The fast-event-triggered CFC charts have the highest priority and are processed before all other tasks. At this level, a considerably 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.

9.3 Supervision of the Secondary System

9.3.1 Overview

The secondary circuits establish a connection to the power system from the point of view of the device. The measuring-input circuit (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.

9.3.2 Measuring-Voltage Failure

9.3.2.1 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 (blocking/no block) to a measuring voltage failure can be set within the function:

- Directional time-overcurrent protection, phases
- 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

The following protection functions are automatically blocked in the case of a measuring-voltage failure:

- Distance protection
- Directional negative-sequence protection
- Ground-fault protection for high-resistance faults in grounded-neutral systems

9.3.2.2 Structure of the Function

This function is part of protection function groups which are connected with a 3-phase voltage and current measurement point.

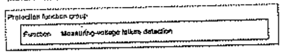

Figure 9-4 Structure/Embedding of the Function

The function is broken down into 3 subfunctions (see Figure 9-5):

- Supervision for unbalanced measuring-voltage failure
- Supervision for 3-phase measuring-voltage failure
- Supervision for switching onto a 3-phase measuring-voltage failure

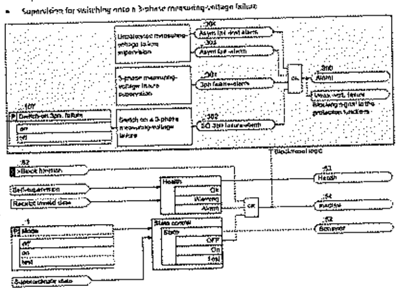

Figure 9-5 Breakdown of the Measuring Voltage Failure Detection Function

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.

9.3.2.3 Unbalanced Measuring-Voltage Failure

Logic

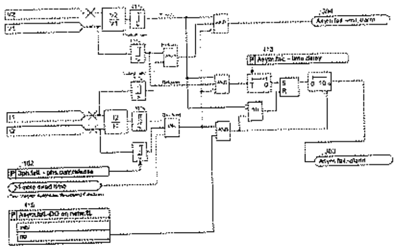

Figure 9-6 Logic Diagram Unbalanced Measuring-Voltage Failure Detection

The criterion for detection of an unbalanced measuring-voltage failure is the voltage unbalance. The 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 9-6). 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 measurands or a measurand of 0 (for example, circuit breaker open). Instantaneous monitoring also requires the presence of a minimum current. This prevents a spurious instantaneous pickup 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.

9.3.2.4 3-Phase Measuring-Voltage Failure

Logic

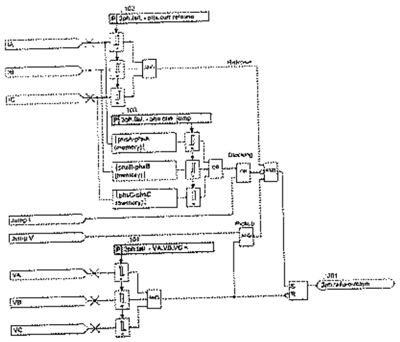

Figure 9-7 Logic Diagram 3-Phase Measuring Voltage Failure

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 as 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.

NOTE

If a voltage transformer circuit-breaker is installed in the secondary circuit of the voltage transformer, its position is communicated to the device via a binary input (see chapter 9.3.4.1 Overview of Functions).

9.3.2.5 Switching onto a 3-Phase Measuring-Voltage Failure, Low Load

Logic

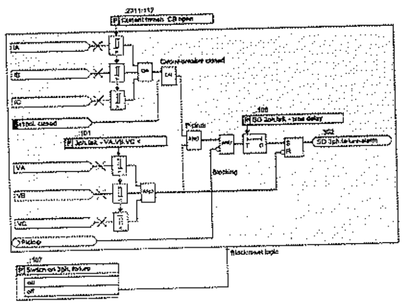

Figure 9-8 Logic Diagram Switching to 3 Phase Measuring Voltage Failure

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 21-pole closed signal, which is generated via the circuit-breaker auxiliary contacts. You can find more detailed information in chapter 5.8.5 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 9.3.2.4 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 supervision 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 9.3.2.4 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.

9.3.2.6 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 value 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 0 s 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 that subfunction on.
off	With the setting off the subfunction Switching to a 3-phase measuring-voltage failure is not active.

9.3.2.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Mea.v.fail.det				
_:1	Mea.v.fail.det:Mode		• off • on • test	on
_:115	Mea.v.fail.det:Asym.fail.-DO on netw.flt.		• no • yes	yes
_:113	Mea.v.fail.det:Asym.fail. - time delay		0.00 s to 30.00 s	10.00 s
_:102	Mea.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	0.500 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	0.500 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

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Addr.	Parameter	C	Setting Options	Default Setting
_:103	Mes.v.fail.det:3ph.fail.-phs.cur. jump	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	Mes.v.fail.det:3ph. fail VA,VB,VC <		0.300 V to 340.000 V	5.000 V
_:107	Mes.v.fail.det:Switch on 3ph. failure		• off • on	on
_:106	Mes.v.fail.det:SO 3ph.fail. - time delay		0.01 s to 30.00 s	3.00 s

9.3.2.8 Information List

No.	Information	Data Class (Type)	Type
Mes.v.fail.det			
_:82	Mes.v.fail.det:>Block function	SPS	I
_:54	Mes.v.fail.det:Inactive	SPS	O
_:52	Mes.v.fail.det:Behavior	ENS	O
_:53	Mes.v.fail.det:Health	ENS	O
_:300	Mes.v.fail.det:Alarm	SPC	O
_:304	Mes.v.fail.det:Asym fail.-inst.alarm	SPS	O
_:303	Mes.v.fail.det:Asym fail. alarm	SPS	O
_:301	Mes.v.fail.det:3ph.failure alarm	SPS	O
_:302	Mes.v.fail.det:SO 3ph failure alarm	SPS	O

9.3.3 Signaling-Voltage Supervision

9.3.3.1 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.

9.3.3.2 Structure of the Function

The Signaling-voltage supervision function group contains, besides the general functionality, one pre-instantiated Supervision group stage. The Supervision group stage can be instantiated in DIGSI 5 multiple times.

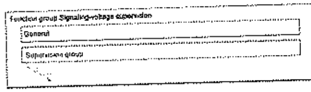
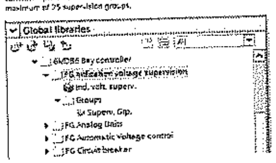


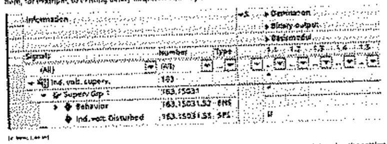
Figure 9.9 Structure/Embedding of the Function Group

9.3.3.3 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.

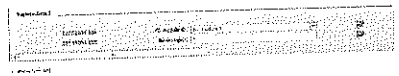


Following the instantiation of the function group in the DIGSI project tree, it appears in the information routing of DIGSI (see the following figure). The status indications of the supervision groups can be routed here, for example, to existing binary outputs and/or logs.



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.

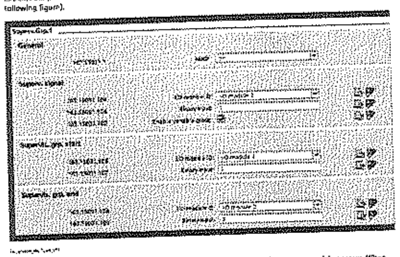
If the signaling voltage again exceeds the binary threshold, the quality attribute of the binary inputs is reset to valid.



NOTE

Each status change of the monitored binary inputs is delayed by 3 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.

9.3.3.4 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 Sig. 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 = untrue

You can activate the parameter Enable variable group by placing the check mark. If you have not set the check mark (default setting), only these 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 carrying out 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.

9.3.3.5 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. 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. 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

9.3.3.6 Information List

No.	Information	Data Class (Type)	Type
Superv.Grp.#			
_:52	Superv.Grp.#:Behavior	ENS	O
_:55	Superv.Grp.#:Sig. volt. disturbed	SPS	O

9.3.4 Voltage-Transformer Circuit Breaker

9.3.4.1 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 3.x Processing Quality Attributes).

The following protection functions are automatically blocked in cases of the tripping of the voltage-transformer circuit breaker:

- Directional negative-sequence protection

For the following functions the reaction (blocking block) can be set within the function in cases of a tripping of the voltage-transformer circuit breaker:

- Directional time-overcurrent protection, phases
- Directional time-overcurrent protection, ground
- Directional sensitive ground-fault detection
- Overvoltage protection with negative-sequence voltage
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 1-phase voltage
- Undervoltage protection with positive-sequence voltage

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9.3.4.2 Structure of the Function

The Figure 9-10 shows the position of the function in the device. Every voltage measuring point contains the Voltage-transformer circuit breaker function.

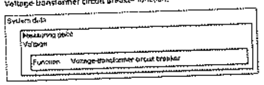

Figure 9-10 Structure/Embedding of the Function

9.3.4.3 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 9.3.4.1 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.

9.3.4.4 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.

9.3.4.5 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

9.3.4.6 Information List

No.	Information	Data Class (Type)	Type
Definite-T #			
_:500	VT miniatureCB:>Open	SPS	I

9.3.5 Voltage-Balance Supervision

9.3.5.1 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.

9.3.5.2 Structure of the Function

The Voltage-balance supervision function is located in the Power-system data of each 3-phase voltage measuring point.

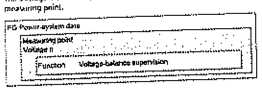

Figure 9-11 Structure/Embedding of the Function

9.3.5.3 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.

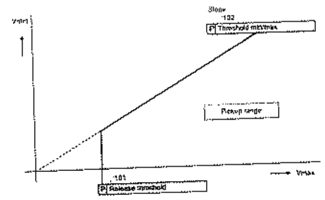

Figure 9-12 Characteristic of the Voltage-Balance Supervision

Logic

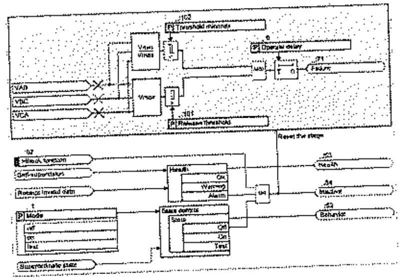

Figure 9-13 Logic Diagram of the Voltage-Balance Supervision

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 this 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.

9.3.5.4 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 voltage. 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.

9.3.5.5 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

9.3.5.6 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

9.3.6 Voltage-Sum Supervision

9.3.6.1 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.

9.3.6.2 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.

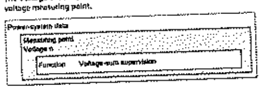

Figure 9-14 Structure/Embedding of the Function

9.3.6.3 Function Description

The voltage sum is generated by addition of the voltage phasors. Errors in the voltage circuits are detected if VF = |VA + VB + VC − Vph/VN · VN| > Threshold, where Vph/VN forms the Matching ratio Vph / VN parameter.

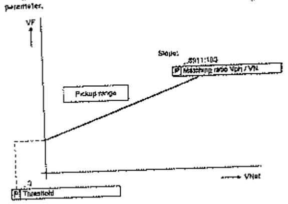

Figure 9-15 Characteristic of the Voltage-Balance Supervision

Logic

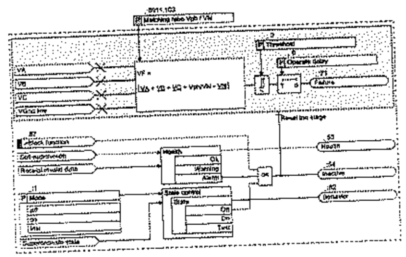

Figure 9-16 Logic Diagram of the Voltage-Sum Supervision

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:

VF = |VA + VB + VC + Vph/VN · VN |, 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 respect can be found in chapter 9.3.6.1 Overview of Functions.

Operate delay

When the threshold value for the Operate delay is exceeded, the indication Failure is generated.

9.3.6.4 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 = 5.00 s

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Set the Operate delay parameter so that overfunctions due to disturbing influences (such as switching operations) are avoided. Siemens recommends using the default setting.

9.3.6.5 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

9.3.6.6 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

9.3.7 Voltage Phase-Rotation Supervision

9.3.7.1 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.

9.3.7.2 Structure of the Function

The **Voltage phase-rotation supervision** function is located in the **Power-system data** of each 3-phase voltage measuring point.

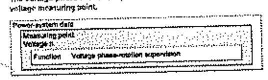

Figure 9-17 Structure/Embedding of the Function

9.3.7.3 Function Description

Logic

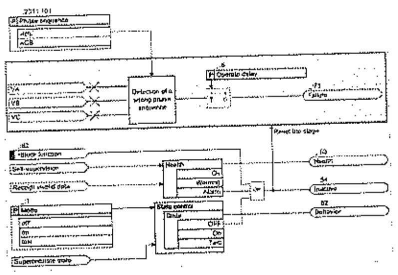

Figure 9-18 Logic Diagram for the Voltage Phase-Rotation Supervision

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.

9.3.7.4 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.

9.3.7.5 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

9.3.7.6 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

9.3.8 Broken-Wire Detection

9.3.8.1 Overview of Functions

The purpose of the broken-wire detection is to detect interruptions in the secondary circuit of the current transformers during steady-state operation.

9.3.8.2 Structure of the Function

The **Broken-wire detection** function is located in the power-system data of each 3-phase current measuring point.

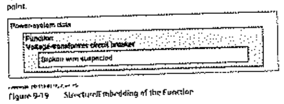

Figure 9-19 Structure/Embedding of the Function

The tasks of Broken-wire detection are:

- The instantaneous values of all current measuring points are checked on a phase-selective basis for implausible values.
- The affected phases are marked with wire-break suspected.
- Depending on the supervision mode, you can add a marker for blocking protection functions for the affected phases.
- After 10 ms of broken-wire check, the wire break is reliably signaled

9.3.8.3 Function Description

Broken Wire Suspected

The **Broken-wire detection** function monitors the dynamic behavior of the currents of each phase and of all measuring points. For this purpose, the instantaneous values of the currents are checked for their plausibility. Each expected violation must be confirmed by additional criteria before a wire break can be detected and signaled with assurance.

The detection of the local broken wire suspected is performed on each 3-phase current measuring point of the device selectively for each phase.

Detection:

A wire break initially manifests itself as a sudden decrease of the current below the minimum threshold of 0.06 I_{rated}. A plausibility test on one period of past instantaneous values confirms this condition. If the criteria for the local wire break are satisfied, the affected phase is marked with **Broken wire suspected**.

Resetting:

The broken wire suspected is reset by phase current flowing again or by a binary input signal. Binary resetting can be useful during laboratory tests among other applications.

Indication

If the broken-wire detection has not been reset within 10 ms, it will be indicated. The indication is held stable for the duration of at least 3 periods.

When using the fast measuring transducer inputs as 4 mA to 20 mA inputs, broken-wire detection is active. With a < 2 mA current, wire breaks are detected and the *wire break* indication is set. The measured values display remains unaffected.

9.3.8.4 Application and Setting Notes

Parameter: Mode

- Recommended setting value (_:1) Mode = *off*

The Mode parameter is used to switch the broken-wire detection to on, *off* and *test*.

9.3.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Brk.wire det.				
_:1	Brk.wire det.:Mode		• off • on • test	off

9.3.8.6 Information List

No.	Information	Data Class (Type)	Type
Brk.wire det.			
_:82	Brk.wire det.:>Block function	SPS	I
_:54	Brk.wire det.:Inactive	SPS	O
_:52	Brk.wire det.:Behavior	ENS	O
_:53	Brk.wire det.:Health	ENS	O
_:301	Brk.wire det.:Phs A BW suspected	SPS	O
_:302	Brk.wire det.:Phs B BW suspected	SPS	O
_:303	Brk.wire det.:Phs C BW suspected	SPS	O
_:304	Brk.wire det.:Phase A broken wire	SPS	O
_:305	Brk.wire det.:Phase B broken wire	SPS	O
_:306	Brk.wire det.:Phase C broken wire	SPS	O

No.	Information	Data Class (Type)	Type
_:307	Brk.wire det.:Broken wire suspected	SPS	O
_:308	Brk.wire det.:Broken wire confirmed	SPS	O

9.3.9 Current-Balance Supervision

9.3.9.1 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.

9.3.9.2 Structure of the Function

The **Current-balance supervision** function is located in the **Power-system data** of each 3-phase current measuring point.

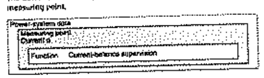

Figure 9-20 Structure/Embedding of the Function

9.3.9.3 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.

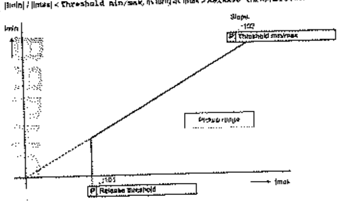

Figure 9-21 Characteristic of the Current-Balance Supervision

Logic

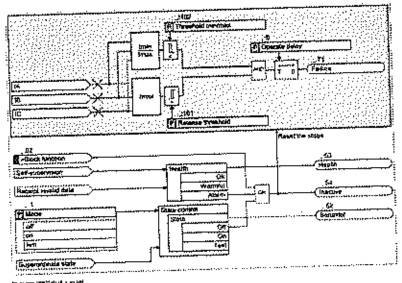

Figure 9-22 Logic Diagram of the Current-Balance Supervision

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.

9.3.9.4 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}).

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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.

9.3.9.5 **Settings**

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. I				
_:1	Supv. bal. 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

9.3.9.6 **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

9.3.10 Current-Sum Supervision

9.3.10.1 **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-12 in the Attachment)
- Ground current detected with 3 separate ground-current transformers (see Figure A-11 in the Attachment)
- 3 current transformers and one summation current transformer connected (see Figure A-13 in the Attachment)
- 2 current transformers and one summation current transformer connected (see A.7 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).

9.3.10.2 **Structure of the Function**

The Current-sum supervision function is located in the Power-system data of each 3-phase current measurement point.

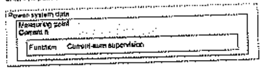

Figure 9-23 Structure/Embedding of the Function

9.3.10.3 **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|.

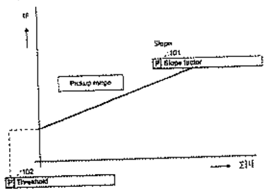

Figure 9-24 Characteristic of the Current-Sum Supervision

Logic

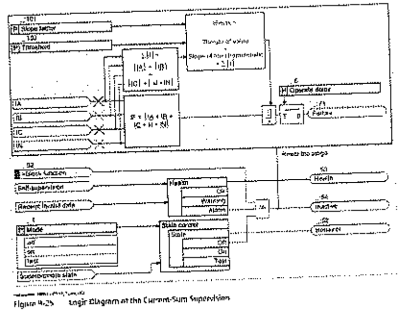

Figure 9-25 Logic Diagram of the Current-Sum Supervision

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_{Fmax}) for the current-sum supervision. The device calculates this fault current limit with the formula:

I_{Fmax} = `Threshold` + `Slope factor` · Σ|I|

The device uses the current inputs (IA, IB, IC and IN) to calculate:

- The fault current IF = |IA + IB + IC + kI · IN|
- The maximum current Σ|I| = |IA| + |IB| + |IC| + |kI · IN|

with k_I taking into account a possible difference from the transformation ratio of a separated ground-current transformer (I_4), 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_{Fmax}), the `Operate delay` starts. If the threshold-value violation persists for that time, the `Failure` indication is generated.

9.3.10.4 **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. This 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.

9.3.10.5 **Settings**

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum I				
_:1	Supv. sum I:Mode		• off • on • test	off
_: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

9.3.10.6 **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

9.3.11 Current Phase-Rotation Supervision

9.3.11.1 **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.

9.3.11.2 **Structure of the Function**

The Current phase rotation supervision function is located in the Power-system data of each 3-phase current measurement point.

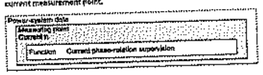

Figure 9-26 Structure/Embedding of the Function

9.3.11.3 **Function Description**

Logic

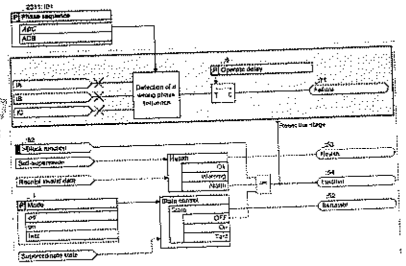

Figure 9-27 Logic Diagram Current Phase Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.
You can find detail of 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 sequence for the duration of the `Operate delay` the indication `Failure` is generated.

9.3.11.4 **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.

9.3.11.5 **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

9.3.11.6 **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

9.3.12 Trip-Circuit Supervision

9.3.12.1 **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 $V_{Ctrl} > 2 V_{BImin}$. 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.

9.3.12.2 **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.

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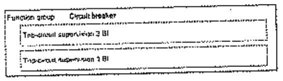

Figure 9-28 Structure/Embedding of the Function

9.3.12.3 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.

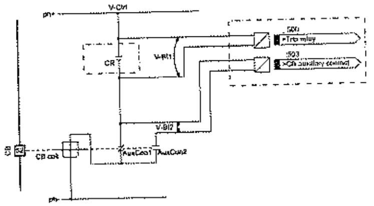

Figure 9-29 Principle of Trip-Circuit Supervision with 2 Binary Inputs

CR Command relay
CB Circuit breaker
CB coil Circuit-breaker coil
AuxCon1 Circuit-breaker auxiliary contact (NC)
AuxCon2 Circuit-breaker auxiliary contact (NO)
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 a 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.

If the binary input signals >Trip relay or >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.

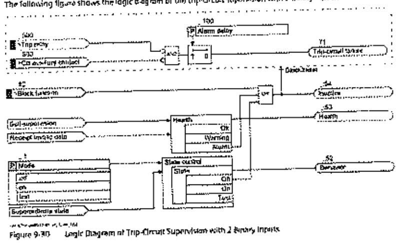

Figure 9-30 Logic Diagram of Trip-Circuit Supervision with 2 Binary Inputs

9.3.12.4 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.

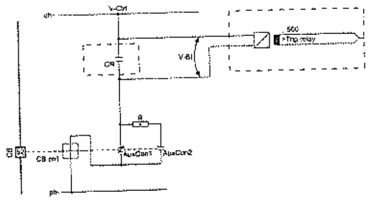

Figure 9-31 Principle of Trip-Circuit Supervision with 1 Binary Input

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)
V-BI 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

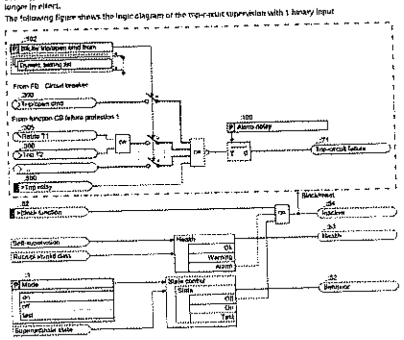

Figure 9-32 Logic Diagram of Trip-Circuit Supervision with 1 Binary Input

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:

$$R_{max} = \left(\frac{V_{Ctrl} - V_{BImin}}{I_{BI(High)}}\right) - R_{CBC}$$

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_{max} and R_{min}:

$$R = \frac{R_{max} + R_{min}}{2}$$

The following applies for the power consumption of the equivalent resistance R:

$$P_R = I^2 \cdot R = \left(\frac{V_{Ctrl}}{R + R_{CBC}}\right)^2 \cdot R$$

9.3.12.5 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.

9.3.12.6 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

9.3.12.7 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

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9.4 Supervision of the Device Hardware

9.4.1 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 signals/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 (magnitude/phase)

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 fault responses at the end of chapter 8. You will find corresponding corrective measures there.

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.

9.4.2 Analog-Channel Supervision via Fast Current-Sum

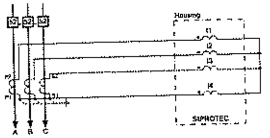
9.4.2.1 Overview of Functions

The function **Supervision of the device-internal analog-digital converters** It performs the following tasks:

- Supervision of the correct functioning of the device-internal analog-digital converters, based on the sum of all currents of 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_N neutral point) (see next figure).



Current transformer 3-phase: connection = 3-phase + IN

Figure 9-33 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.

9.4.2.2 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.

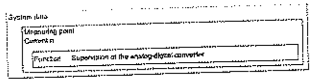


Figure 9-34 Structure/Embedding of the Function

9.4.2.3 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 $\Sigma| i | = |iA|+|iB|+|iC| + |iN|$

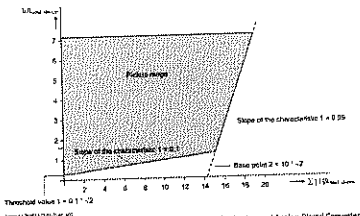


Figure 9-35 Characteristic Curve of the Supervision of the Device-Internal Analog-Digital Converters

Logic

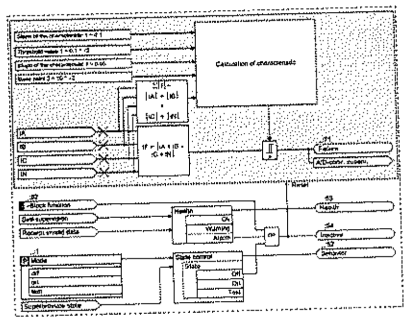


Figure 9-36 Logic Diagram of the Supervision of the Device-Internal Analog-Digital Converters

When the output signal *A/D converter superv.* is active, certain protection functions are blocked to avoid failures (see 12.64 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.

9.5 Supervision of Device Firmware

The device firmware determines essentially the functionality of the device.

The following supervisions ensure the stable function of the device:

- Supervision of the data and version consistency
- Supervision of the undisturbed 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.

9.6 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 the 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 synchronization with DIGSI.

9.7 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 traces 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 9.8.2 Defect Severity 1 to 9.8.4 Defect Severity 3, you will find the detailed description, in tabular form, of the error responses. Corresponding corrective measures can also be found there.

9.8 Error Responses and Corrective Measures

9.8.1 Overview

When device errors occur and the corresponding supervision functions pick up, this is displayed on the device and also indicated. Device errors can 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 preroutred 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 automated 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		

9.8.2 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: (_:52) Health	ENS	CFC	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: (_:319) 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: (_:204) 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: (_:319) 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 E/F/M/N/P: 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 datameas. point I-3ph/wire break: Wiring: (_:301) Phase A possible wire break (_:302) Phase B possible wire break (_:303) Phase C possible wire break (_:304) Phase A wire break (_:305) Phase B wire break (_:306) Phase C wire break (_:307) Possible wire break (_:308) Confirmed wire break	SPS SPS SPS SPS SPS SPS SPS SPS	CFC CFC	Broken-wire detection indications (see chapter 9.3.6.1 Overview of Functions) Blocking: Protection functions tending to overfunction in the event of a wire break are blocked.
Power-system datameas. point I-3ph/superv. sym I (_:71) Failure	SPS	CFC	Current balance failure (see chapter 9.3.7.1 Overview of Functions)
Power-system datameas. point I-3ph/superv. PhsSeq.I: (_:71) Failure	SPS	CFC	Failure of current phase-rotation reversal (see chapter 9.3.11.1 Overview of Functions)
Power-system datameas. point I-3ph/superv. Sum I (_:71) Failure	SPS	CFC	Failure of current sum (see chapter 9.3.10.1 Overview of Functions)
Power system datameas. point I-3ph/superv.ADC sum.I: (_:71) Failure	SPS	CFC	Failure of the quick current sum (see chapter 9.4.2.1 Overview of Functions) The failure indication indicates a fault in the analog-digital converter at the power input. • Check the exterior wiring. • If the fault is not remedied, contact the Customer Support Center. Quality: The internally managed current measured values are marked with the invalid quality attribute. Blocking: The protection functions based on current measurement are blocked.
Power-system datameas. 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 datameas. point V-3ph. Superv. Sym.V: (_:71) Failure	SPS	CFC	Voltage balance failure (see chapter 9.3.5.1 Overview of Functions)
Power system data meas. point V-3ph: Superv. PhsSeq.V: (_:71) Failure	SPS	CFC	Failure of voltage phase-rotation monitoring (see chapter 9.3.7.1 Overview of Functions)

Indication	Type	Group Warning	Explanation
Power-system data/meas. point V 3ph: Superv. of Sum V. (_:71) Failure	SPS	CFC	Failure of voltage sum (see chapter 5.x.6.3 Overview of Functions)
2 devices prot. comm.: Protection interface 1: (_:303) Open connection (_:316) Fault rate/min exceeded (_:317) Fault rate/h exceeded (_:318) Runtime exceeded (_:325) 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 remedied, 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.
VI 3ph: Meas.Volt.Fail detected (_:300) Failure	SPS	CFC	Measuring-voltage failure detected: Check the exterior wiring. **Blocking:** Appropriate functions are either blocked definitely or you can set the blocking individually.

9.8.3 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.

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
825	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.

[1] The indications are not prerouted in the CFC chart. The indications must be added to the CFC chart by the user!

Number	Device-Diagnosis Log
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.

9.8.4 Defect Severity 3

Faults of defect severity 3 are fatal device faults that lead to device immediately going into the fallback mode. The signal (_:301) *Device status* goes to the Alarm state. the Warning state is not supported for that 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 (_:301) *Device status* 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 .

Overview of Errors

Number	Device-Diagnosis Log
2822	Memory error (continuous) Contact the Customer Support Center.
4727, 5018-5028	Hardware failure at module 1-12: Contact the Customer Support Center.
4729	Device bus error (repeated): ▪ Check the module configuration and the module connections. ▪ Contact the Customer Support Center.
4733	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.
5031-5035	Identified wrong plug-in module on plug-in module position E/F/M/N/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.
3640, 4514	Data structure error: Contact the Customer Support Center.

Number	Device-Diagnosis Log
756	Firmware revision 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.
5089, 5082	A missing display configuration was established: Synchronize the hardware configuration of the device with DIGSI.

9.8.5 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 [illegible] group alarm [illegible] 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* 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 9.9 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 .

9.9 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).

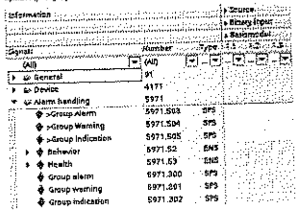


Figure 9-37 Group Monitoring Indication in the DIGSI 5 Information Routing Matrix

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 9.8.5 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 9.8.2 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 prerouted to an LED of the base module.

Group Indication

The *Group indication* is used only for user-specific purposes. There is no internal device-supervising 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.

10 Measured Values, Energy Values, and Supervision of the Primary System

10.1 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.

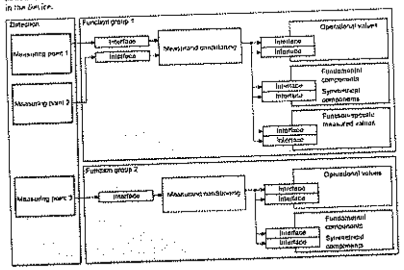


Figure 10-1 Structure of Measured Value Acquisition and Processing

For the display, the measured values of a SIPROTEC 5 device are summed up in the following groups:

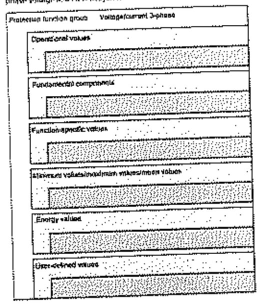
- Operational measured values
- Fundamental and symmetrical components
- Function-specific measured values
- Minimum values, maximum values, average values
- Energy metered values
- User-defined measured and metered values
- Statistic Values

10.2 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

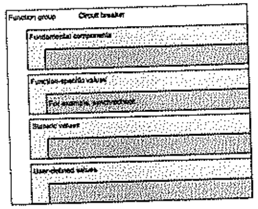
In the simplest version the Voltage/Current 3-phase function group obtains the measured values of the 3-phase voltage and current system and contains the following measured-value groups:



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 10.3 Operational Measured Values - 10.11 Statistical Values of the Primary System.

10.3 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 10-1 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
$3I_0$	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 $V_{rated\ ph} \cdot I_{rated\ ph}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	–	Reactive power of the phase $V_{rated\ ph} \cdot I_{rated\ ph}$
S_A, S_B, S_C	Phase-related apparent power	MVA	–	Apparent power of the phase $V_{rated\ ph} \cdot I_{rated\ ph}$

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

10.4 Fundamental and Symmetrical Components

The fundamental components are calculated from the frequency-tracked instantaneous values through a Fourier filter (integration 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 10-2 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 10-3 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

10.5 Average Values

10.5.1 Function Description of Average Values

Average values can be formed based on different measurands:
- Operational measured values
- Symmetrical components

Through the settings, you can set how and when the average values are formed. The settings describe:
- Time slot over which the average value is formed
  (Parameter: Average calc. interval)
- Update interval for the display of the average values
  (Parameter: Average update interval)
- Synchronization time for establishing the date of commencement updating information, for example, at the top of the hour (hh:00) or at one of the other times (hh:15, hh:30, hh:45).
  (Parameter: Average synchronize. time)

Average values are formed through the following measurands:
- Operational measured values except for phase-related ratings
- Amounts of the symmetrical components

You reset the average value formation via the
- Binary input >Reset average value
- DIGSI
- The integrated operation panel

NOTE

With the P, Q sign parameter in the function block General, the sign of the following measured values of the respective function group can be inverted (see Chapter 10.2 Structure of the Function Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):
- Active power (total): P total
- Reactive power (total): Q total

10.5.2 Application and Setting Notes for Average Values

The average value formation functionality is not preconfigured with the devices in the function group. If you use the functionality, you must load it from the library into the respective function group.
The following settings listed for the calculation of the average values can be set with DIGSI and at the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Average calc. interval

- Default setting: (_:104) Average calc. interval = 60 min

Parameter Value	Description
1 min to 60 min	Time slot for averaging, for example 60 minutes

Parameter: Average update interval

- Default setting: (_:105) Average update interval = 60 min

Parameter Value	Description
1 min to 60 min	Update interval for displaying the average value, for example 60 minutes

Parameter: Average synchroniz. time

- Default setting: (_:106) Average synchroniz. time = hh:00
  The parameter describes the synchronization time for average value formation.

Parameter Value	Description
hh:00	The parameter Average update interval will be effective on the full hour
hh:15	The parameter Average update interval will be effective 15 minutes after the full hour
hh:30	The parameter Average update interval will be effective 30 minutes after the full hour
hh:45	The parameter Average update interval will be effective 45 minutes after the full hour

NOTE

The average value calculation restarts after
- Changing one of the 3 settings for the average-value calculation
- Resetting the device (initial or normal reset)
- Changing the time
- Resetting the average values

The average values are reset immediately. The display changes to '---'.

The following examples explain how to set parameters and to make a change.

Average calc. interval = 60 min
Average update interval = 30 min
Average synchroniz. time = hh:15

A new average value is formed every 30 min, at hh:15 (15 min after the top of the hour) and hh:45 (15 min before the top of the hour). All measured values obtained during the last 60 min are used for average value formation.
If these settings are changed to 11:03:25, for instance, the average values are first reset and '---' appears in the display. The 1st average value is then formed at 12:15:00.
In this example, the Average synchroniz. time = hh:45 acts as described above for = hh:15.

Average calc. interval = 60 min
Average update interval = 60 min
Average synchroniz. time = hh:15

A new average value is formed every 60 min at hh:15 (15 min after the top of the hour). All measured values obtained during the last 60 min are used for average value formation.
If these settings are changed to 11:03:25, for instance, the average values are first reset and '---' appears in the display. The 1st average value is then formed at 12:15:00.

Average calc. interval = 5 min
Average update interval = 10 min
Average synchroniz. time = hh:00

A new average value is formed every 10 min at hh:00, hh:10, hh:20, hh:30, hh:40, hh:50. All measured values obtained during the last 5 min are used to form the average value.
If these settings are changed to 11:03:20, for instance, the average values are first reset and '---' appears in the display. The 1st average value is then formed at 11:10:00.

10.6 Minimum/Maximum Values

10.6.1 Function Description of Minimum/Maximum Values

Minimum and maximum values can be formed based on different measured or calculated measurands:
- Operational measured values
- Symmetrical components
- Selected values

You can set which measurand will be used. The measurands for the minimum/maximum formation are loaded from DIGSI.
Calculation and resetting of the minimum and maximum values are controlled through settings. The settings describe the following points:
- Memories of the minimum/maximum values are reset to 0 cyclically or not at all.
  (Setting Min/Max cyclic reset)
- Point in time when the memories of the minimum/maximum values are reset to 0.
  (Setting Min/Max reset each and setting Min/Max reset minute)
- Point in time at which the cyclical reset procedure of the minimum/maximum values begins (after the parameterization)
  (Setting Min/Max days until start)

The following figure shows the effect of the settings.

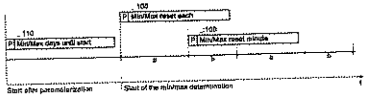


Figure 10-2 Minimum and Maximum-Value Formation

Minimum and maximum values are time-stamped.
Minimum/maximum values are formed through:
- Operational measured values except for phase-related ratings
- Amounts of the symmetrical components
- Average values

The minimum and maximum values are reset on a regular basis or via the
- Binary input >Reset minimax
- DIGSI
- The integrated operation panel

NOTE

With the P, Q sign parameter in the function block **General**, the sign of the following measured values of the respective function group can be inverted (see Chapter 10.2 *Structure of the Function Structure of the Function*, section Inversion of Output-Related Measured and Statistical Values):
- Minimum/maximum values of the active and reactive power:
  Min:Ptotal, Max:Ptotal, Min:Qtotal, Max:Qtotal
- Minimum/maximum values of the average values of the active and reactive power:
  AverageMin:Ptotal, AverageMax:Ptotal, AverageMin:Qtotal, AverageMax:Qtotal

10.6.2 Application and Setting Notes for Minimum/Maximum Values

The minimum/maximum values functionality is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.
The following settings listed for the calculation of the minimum/maximum values can be set with DIGSI or at the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Min/Max cyclic reset

- Default setting: (_:107) Min/Max cyclic reset = yes

Parameter Value	Description
Yes	Cyclical resetting of the minimum and maximum value memories is activated
No	Cyclical resetting of the minimum and maximum value memories is deactivated None of the following parameters are visible

Parameter: Min/Max reset each

- Default setting: (_:108) Min/Max reset each = 1 day

Parameter Value	Description
1 day to 365 days	Resetting of the minimum value and the maximum value, cyclically on all specified days, for example each day (1 day)

Parameter: Min/Max reset minute

- Default setting: (_:109) Min/Max reset minute = 0 min

Parameter Value	Description
0 min to 1439 min	Resetting the minimum value and the maximum value at the specified minute of the day, which is stated in the parameter Min/Max Reset takes place every, for example 0 min (= 00:00)

Parameter: Min/Max days until start

- Default setting: (_:110) Min/Max days until start = 1 day

Parameter Value	Description
1 day to 365 days	Indication of when the cyclical reset procedure of the minimum values and maximum values begins, for example in 1 day (after the parameterization)

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10.7 Energy Values

10.7.1 Function Description of Energy Values

The device continually determines the values for the active and reactive energy from the power measured values. It calculates the exported and imported electrical energy. The calculation (summation over time) begins immediately after the device startup. You can read the present energy values on the device display or through DIGSI, delete the energy value (set to 0), or set it to any initial value. After input, the energy value calculation will continue with the new setting values.

Energy values can be transferred to a control center through an interface. The energy values are converted into energy metered values. Here the following applies:

$$\text{Energy metered value} = \frac{\text{Energy value}}{S_{nom}} \cdot 60000 \frac{\text{Pulses}}{\text{h}}$$

Through the settings, you set how the metered values are processed. The setting parameters apply for all energy metered values of the device, and do not have a function-group specific effect. You determine the following points:

- Parameter `Energy restore time`
  Hour-related point in time at this point in time, the device will provide a metered value at the communication interface for transmission. After this, it will be transferred in accordance with the selected log.
  Note: If the parameter is activated through a time setting, the parameter `Energy restore interval` will automatically be deactivated.
- Parameter `Energy restore interval`
  Adjustable period in minutes until the first and every further transfer of the metered value to the communication interface of the device. After this, it will be transferred in accordance with the selected log.
  Note: The transfer interval is used alternatively to the transfer time, and deactivates the set transfer time. The display of the device is always up to date.
  You will find these parameters in the device settings under **measured values**.

In addition, restoring can be triggered via a routable binary input (`>Restoring`). The rising edge of the binary input leads to restoring, that is, provision of the energy metered value at the communication interface.

The metered-value memory and the energy values can be set to 0 via a binary input (`>Resetting`) if there is a rising edge.

Note: The binary inputs affect all energy/energy metered values simultaneously.

The following energy values are available:

Energy Values		Primary
Wp+	Active energy, output	kWh, MWh, GWh
Wp-	Active energy, input	kWh, MWh, GWh
Wq+	Reactive energy, output	kvarh, Mvarh, Gvarh
Wq-	Reactive energy, input	kvarh, Mvarh, Gvarh

In compliance with IEC 61850, when individually measured values are missing, the quality of the energy-metered values changes to the state **Questionable**.

This quality state is retained until a new meter content is specified for the energy value by:

- Confirmation of the current meter content via **Set**
- Setting a new meter content
- Resetting the meter content to 0

NOTE

With the P, Q sign parameter in the function block General, the sign of the following measured values of the respective function group can be inverted (see Chapter 10.2 Structure of the Function Structure of the Function, Section Inversion of Output-Related Measured and Statistical Values):

- Active energy, output: Wp+
- Active energy, input: Wp-
- Reactive energy, output: Wq+
- Reactive energy, input: Wq-

10.7.2 Application and Setting Notes for Energy Values

The set parameters apply for all electrical meters of the device. You find the setting parameters in DIGSI in the project tree under **Settings > Device settings**.

Parameter: Energy restore interval

- Default setting: (_:111) `Energy restore interval` = 10 min

Parameter Values	Description
0 min	Restoring deactivated
60 min	Cyclical restoring after the set time 1 minute to 60 minutes

Note: If the parameter is activated through a time setting, the parameter `Energy restore time` is not in effect and will be deactivated automatically.

Parameter: Energy restore time

- Default setting: (_:112) `Energy restore time` = --

Parameter Value	Description
--	Deactivated
hh:00	Restoring on the full hour
hh:15	Restoring 15 minutes after the full hour
hh:30	Restoring 30 minutes after the full hour
hh:45	Restoring 45 minutes after the full hour

Note: If the parameter is activated through a time setting, the parameter `Energy restore interval` is not in effect and will be deactivated automatically.

Parameter: Energy restore

- Default setting: (_:170) `Energy restore` = `latest value`

Parameter Value	Description
`latest value`	Restoring of the current energy value
`delta value`	Restoring the difference value between the current energy value and the energy value of the last restoring operation

Parameter: Energy restore by A.time

- Default setting: (_:121) `Energy restore by A.time` = `wrong`

Parameter Value	Description
`wrong`	Restoring deactivated

Parameter Value	Description
`true`	The cyclic restoring after the set time of the parameter (_:111) `Energy restore interval` will be synchronized with the system time as well. Example: `Energy restore interval` = 30 min; current system time: 12:10 o'clock. First restore: 12:30 o'clock, next restore: 13:00 o'clock etc.

Note: If the parameter is activated, the following setting values are possible for the parameter (_:111) `Energy restore interval`: 1 min; 2 min; 3 min; 4 min; 5 min; 6 min; 10 min; 12 min; 15 min; 20 min; 30 min; 60 min.

Input Signals: >Restoring and >Resetting

Binary Inputs	Description
>Restoring	The restoring of the metered values is initiated via a binary input.
>Reset	The metered value memory is set to 0 through the binary input.

You route these logical signals in the DIGSI routing matrix. Open the function group, for example, Line, where you created the energy value. Under the tab **Measured values** you will find the tab **Energy, 3-phase**. In this tab, you will find the logical signals in addition to the measured values.

10.8 User-Defined Metered Values

10.8.1 Pulse-Metered Values Function Description

NOTE

You can define additional metered values through DIGSI for user specific applications.

Use pulse meters, then you can define the respective metered values through DIGSI and set parameters for them analogously to the energy values. You can read out the metered values on the display of the device or via DIGSI.

Through settings, you can individually set how each pulse-metered value is processed:

- Parameter `Restore time`
  Hour-related point in time when the device will provide a metered value at the communication interface for transmission. After this, the transfer takes place in accordance with the selected protocol.
  Note: If the parameter is activated through a time setting, the parameter `Restore interval` will automatically be deactivated.
- Parameter `Restore interval`
  Adjustable period in minutes until the first and every further transfer of the metered value to the communication interface of the device. After this, it will be transferred in accordance with the selected log.
  Note: If the parameter is activated through a time setting, the parameter `Restore time` will automatically be deactivated.

In addition, restoring can be triggered via a routable binary input (`>Restore trigger`) or via a logical internal binary input. The rising edge of the binary input leads to restoring and thus to provision of the metered value at the communication interface.

The counter pulse of any external/internal pulse generator is connected to the device via a routable binary input (`>Pulse input`). If this does not deliver any plausible values, this can be signaled to the device via another routable binary input (`>External error`).

In compliance with IEC 61850, in the event of an external error, the quality of the pulse-metered value changes to the state **Questionable**. No more pulses are added as long as the external error persists. Once the external fault condition has been cleared, pulses are added again.

The quality of the pulse-metered value remains **Questionable** until a new meter content is specified for the pulse-metered value by:

- Confirmation of the current meter content via **Setting**
- Setting a new meter content
- Resetting the meter content to 0

- Parameter `Edge trigger`
  Through settings, you can select between counting only with a rising edge or with rising and falling edges on the pulse input.

The pulse counter can be reset to 0. You can perform this resetting via the rising edge of a routable binary input (`>Reset`) or via operation on the device.

To display the counting amount at the device display, use DIGSI to set the desired weighting of the counter pulses, the unit of the metered value and a multiplication factor for every pulse generator. You can also assign a user-specific name.

To do this, open the functional area **Pulse-metered value** in DIGSI Information routing (see Figure 10-3). Select the metered value and enter the settings under **Properties**.

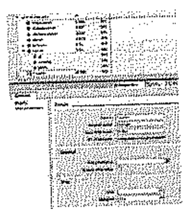

Figure 10-3 Setting with DIGSI, General Settings, Pulse-Metered Values

10.8.2 Application and Setting Notes for Pulse-Metered Values

The functionality Pulse-metered values is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.

The parameters can be set individually for every pulse counter. You will find the setting parameters in DIGSI in the project tree under **Parameter > Function group**

For pulse-metered values, the following described settings and binary inputs are available.

Parameter: `Restore time`

- Default setting: (_:101) `Restore time` = --

Parameter Value	Description
--	Deactivated
hh:00	Transfer on the full hour
hh:15	Transfer 15 minutes after the full hour Note
hh:30	Transfer 30 minutes after the full hour Note:
hh:45	Transfer 45 minutes after the full hour Note:

Note: If the parameter is activated through a time setting, the parameter `Restore interval` is not in effect and will be deactivated automatically.

Parameter: `Restore interval`

- Default setting: (_:102) `Restore interval` = 0 min

Parameter Value	Description
0 min	Deactivated
1 min to 60 min	Cyclical transfer after the set time 1 minute to 60 minutes

Note: If the parameter is activated through a time setting, the parameter `Restore time` is not in effect and will be deactivated automatically.

Parameter: `Edge trigger`

- Default setting: (_:103) `Edge trigger` = `rising edge`

Parameter Value	Description
`rising edge`	Counting with rising edge at the pulse input
`rising & falling edge`	Counting with rising and falling edge at the pulse input

Parameter: `Restore by absolute time`

- Default setting: (_:104) `Restore by absolute time` = `false`

Parameter Value	Description
`false`	Deactivated
`true`	The cyclic restoring of setting `Restore interval` after the set time is also synchronized with the system time. Example: `Restore interval` = 30 min; current system time: 12:10 o'clock. First restoring operation: 12:30 o'clock; next restoring operation: 13:00 o'clock, etc.

Input Signals: >Pulse input, >External error, >Restore trigger, >Reset

Binary Inputs	Description
>Pulse input	Input for the counting pulses of an external pulse generator
>External error	Indication that the counter pulses of the external pulse generator are faulty. The indication has an effect on the quality identifier of the pulse value.
>Restore trigger	The transfer of the metered values is initiated via a binary input.
>Reset	The rising edge at the binary input resets the pulse counter to 0.

The amount of energy indicated by a pulse generator is to be displayed as a measured value.

1 pulse corresponds to 100 Wh.

The pulse weighting, the SI unit, and the factor must be adjusted to one another.

Display value = Calculated metered value * Pulse weighting * Factor * SI unit.

If the check box Restore delta value is activated, the differential value is transferred at the restore time set via the communication interface. The difference value is formed by subtracting the counter content of the last restoring operation from the current counter content.

You route the logical signal `>Pulse input` to a binary input to which the pulse generator is connected.

Set the following values:

Name	Active Power Meter
Pulse weighting	100
Restore differential value	Activated
SI unit	Wh
Factor	1

The factor is used for adaptation to larger units (for instance, 1000 for kWh). It is adjustable in powers of ten (1, 10, 100, 1000, etc.). The following figure shows the signals that can be arranged in the DIGSI information matrix. Open the function group where you created the pulse-metered value, for example, Line 1. There, you will find the function area Pulse-metered value. Here you will also find the logical signals next to the metered value. Select the metered value and enter the settings under Properties.

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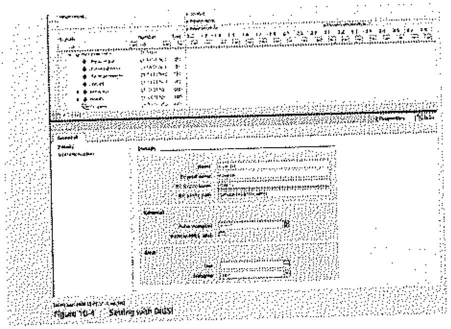

Figure 10-4 Setting with DIGSI

10.9 Phasor Measurement Unit (PMU)

10.9.1 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.

10.9.2 Structure of the Function Group

The PMU function group is activated by selecting the protocol *IEEE C37.118PMU* 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).

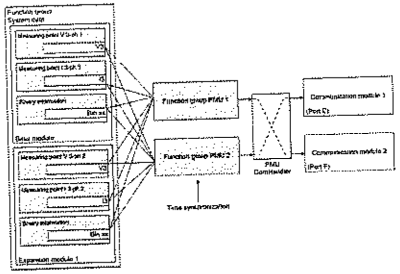

Figure 10-5 Structure/Embedding of the Function

10.9.3 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.

Table 10-4 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.

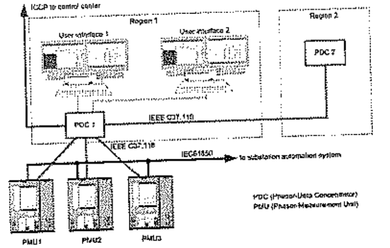

Figure 10-6 Structure of a Wide-Area Monitoring System with Phasor-Measurement Units

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 $\underline{v}(t) = \underline{V}e^{j\omega t}$ can be displayed as a phasor that moves counterclockwise in the complex plane at the angular frequency ω. Therefore, the voltage function $v(t) = Re\{\underline{v}(t)\}$ is obtained as a projection of the phasor $\underline{v}(t)$ on the real axis.

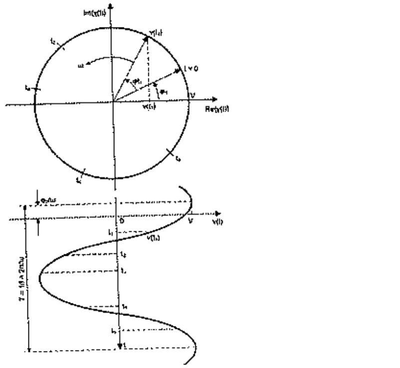

Figure 10-7 Geometric Representation of a Phasor

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 10-8).

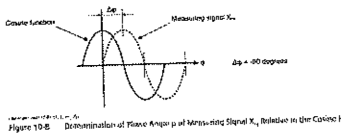

Figure 10-8 Determination of Phase Angle φ of Measuring Signal X_M Relative to the Cosine Function

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 compiled 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 37.118 defines upper limiting values of 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.

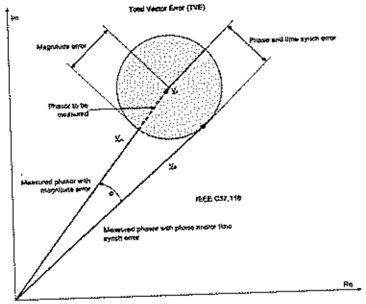

Figure 10-9 Representation of the Total Vector Error

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.

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10.9.4 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.

10.9.5 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 close 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 10.9.6 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 10-5 Possible 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
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 ID03

Table 10-6 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.

10.9.6 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 10-10. You can view the selected port in the (_:10621:104) Port. This parameter is automatically managed by DIGSI and cannot be changed.

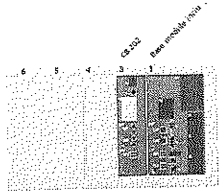

Figure 10-10 Placement of Communication Modules

NOTE

Port M of the CB202 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 Item Ethernet addresses and so forms the IP address for the respective PMU.

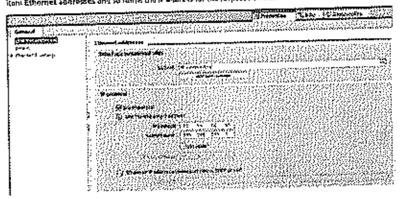

Figure 10-11 Ethernet Address Configuration

In the DIGSI properties dialog for channel 1, select the synchrophasor protocol, see the following figure.

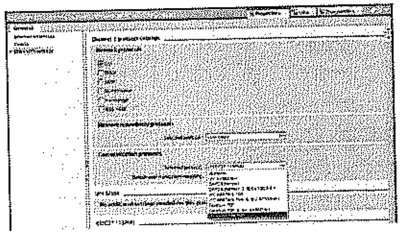

Figure 10-12 Protocol Selection

After you have selected the synchrophasor protocol for the communication module, an advanced settings dialog for PMU-specific configuration opens, see the following figure.

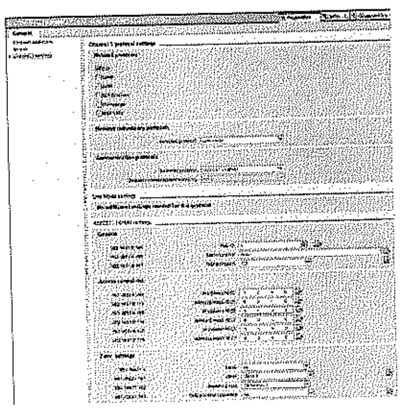

Figure 10-13 PMU-Specific Configuration

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 accesses. 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 10-14 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 10-15.

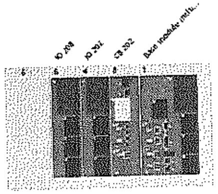

Figure 10-14 Adding Additional Input/Output Modules

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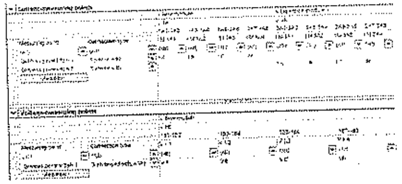

Figure 10-15 Assignment of the Current and Voltage Inputs of the Added Input/Output Modules on Measuring Points

The maximum number 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.

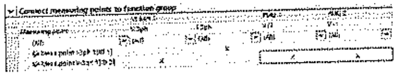

Figure 10-16 Connecting Measuring Points to the Configured PMU Function Groups

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 of 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).

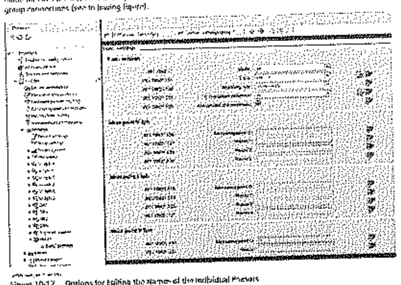

Figure 10-17 Options for Editing the Names of the Individual Phasors

NOTE

You can only rename each individual phasor when you set the parameter Positive-sequence system only to No in the functional settings. 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.

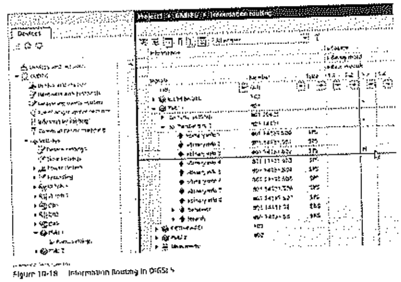

Figure 10-18 Information Routing in DIGSI 5

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.

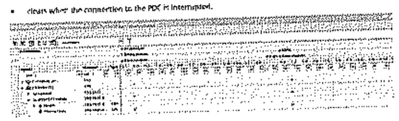

Figure 10-19 Log Indication for Display of the PMU/PDC Connection

10.9.7 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 10-20). Note that the parameter Port cannot be changed, because this corresponds to the physical slot position of the communication module in question.

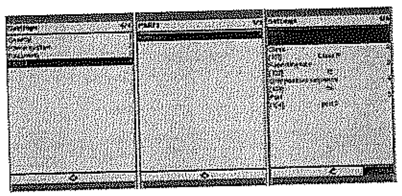

Figure 10-20 Changing the PMU Setting Values via the Device Display

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 10-21).

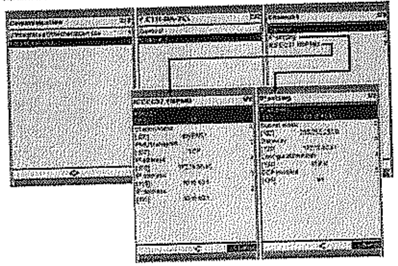

Figure 10-21 Changing the Communication Setting Values via the Device Display

10.9.8 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.

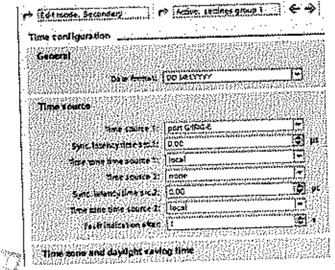

Figure 10-22 Setting Time Synchronization

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.

10.9.9 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 frame/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

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Addr.	Parameter	C	Setting Options	Default Setting
Meas.point V-1ph				
_:10621:130	Func. settings:Measuring point ID		0 to 0	0
_:10621:131	Func. settings:Phasor		Freely editable text	
Meas.point V-1ph				
_:10621:133	Func. settings:Measuring point ID		0 to 0	0
_:10621:134	Func. settings:Phasor		Freely editable text	
Meas.point I-1ph				
_:10621:136	Func. settings:Measuring point ID		0 to 0	0
_:10621:137	Func. settings:Phasor		Freely editable text	
Meas.point I-1ph				
_: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	

10.9.10 Information List

No.	Information	Data Class (Type)	Type
General			
_:10621:52	Func. settings:Behavior	ENS	O
_:10621:53	Func. settings:Health	ENS	O

10.10 Measuring Transducers

10.10.1 Overview of Functions

Measuring transducers with an input rated at 20 mA can be used in the device. 4 such inputs are available as module ANAI-CA-4EL, which can be plugged into a communication module slot (for instance, port E or F). Up to 4 such modules can be plugged in. Typically, slowly changing process variables such as temperature or gas pressure are recorded with such 20 mA measured values and reported to the substation automation technology.

10.10.2 Structure of the Function

The measuring-transducer blocks are embedded in the Analog units function group and contain input and output channels that are configurable independently of each other.

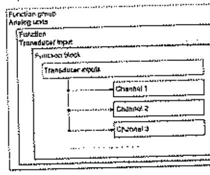

Figure 10-23 Structure/Embedding of the Function

10.10.3 Function Description

The 20 mA inputs typically transmit a value which represents a physical quantity such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that assigns the physical quantity to the 20-mA value. If the parameter Range active is not activated (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA. The following figure shows an example.

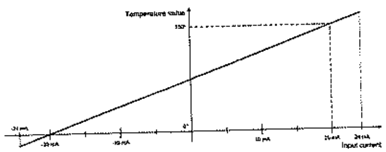

Figure 10-24 Characteristic Curve of a 20-mA Input (Example 1)

In this example, the measured value -20 mA means a temperature of 0 degrees Celsius and the measured value 20 mA a temperature of 100 degrees Celsius. Thus, Unit = °C and Conversion factor = 100 are entered. The resolution (decimal place) of the temperature value can be chosen; for a decimal place, select Resolution = 0.1.

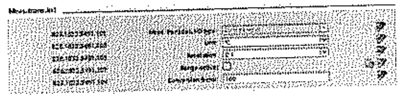

Figure 10-25 Settings for Example 1

If a value smaller than -24 mA or larger than +24 mA is applied to the measuring-transducer input, the measured value is marked as invalid. If the parameter Range active is activated, the 2 additional parameters Upper limit and Lower limit appear. Both limiting values indicate the input currents in mA, for which the value set by the Conversion factor (Upper limit) and the value 0 (Lower limit) of the calculated measurand are valid (see following figure).

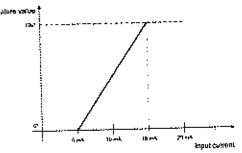

Figure 10-26 Characteristic Curve of a 20-mA Input (Example 2)

In this example, Range active is selected. The Upper limit is at 15 mA, the Lower limit is at 5 mA and the Conversion factor remains at 100. The total results in a characteristic curve as shown in the following figure, taking into account all possible valid measured values from -24 mA to +24 mA. The parameter Upper limit - Sensor is the calculated measured value if the input current corresponds to the value in the Upper limit setting. The parameter Lower limit - Sensor is the calculated measured value if the input current corresponds to the value in the Lower limit setting.

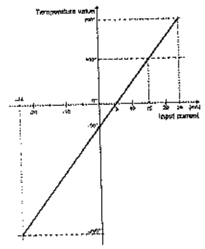

Figure 10-27 Total Characteristic Curve in Example 2

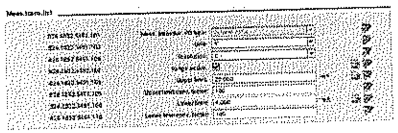

Figure 10-28 Settings for Example 2

Each measuring transducer makes available the scaled measured value in the information matrix (these are the temperature values in the examples) and the original current measured value in mA for further processing. The measuring-transducer values can be displayed in the display image and processed with CFC charts.

10.10.4 Application and Setting Notes

Parameter: Unit

- Recommended setting value (_:103) Unit = °C

You use the setting Unit to specify which physical unit of measurement the measured values represent. The possible setting values are listed in the settings table.

Parameter: Conversion factor

The (_:104) Conversion factor setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting (_:108) Resolution = 0.1

The Resolution setting is used to specify the measured value resolution.

Parameter: Range active

- Default setting (_:107) Range active = false

If you do not activate the Range active setting (no x in the check box), the function operates over the range -24 mA to +24 mA. The setting of the range for the scaled value goes from a usable range of -20 mA to +20 mA.

If you activate the Range active setting, then 4 additional settings Upper limit, Upper limit - Sensor, Lower limit and Lower limit - Sensor appear.

Parameter: Upper limit, Lower limit, Upper limit - Sensor and Lower limit - Sensor

- Default setting (_:105) Upper limit = 20000 mA
- Default setting (_:106) Upper limit - Sensor = 100
- Default setting (_:106) Lower limit = 4000 mA
- Default setting (_:110) Lower limit - Sensor = 100

If you activate the Range active setting, then 4 additional settings Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor appear. The setting Upper limit - Sensor is the calculated measured value if the input current corresponds to the value in the Upper limit setting. The setting Lower limit - Sensor is the calculated measured value if the input current corresponds to the value in the Lower limit setting.

10.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT in #				
_:101	MT in #:Meas. transdu. I/O type		• Voltage input • Current input • Voltage output • Current output • Temperature input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• • u • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • m • J • J/Wh • K • l/s • m • ms • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • W • Wh	m
_:108	MT in #:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		1 to 100000	100
_:105	MT in #:Upper limit		20.00 mA to 20.00 mA	20.00 mA
_:109	MT in #:Upper limit - Sensor		-10000 to 10000	100
_:106	MT in #:Lower limit		-20.00 mA to 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-10000 to 10000	100

10.10.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:301	MT in #:TD scale MV	MV	O
_:302	MT in #:TD direct MV	MV	O

10.11 Statistical Values of the Primary System

The device provides statistical values for circuit breakers and disconnectors.

The following values are available for each circuit-breaker:

- Total number of trippings of the circuit-breaker initiated by the device.
- Number of trippings of the circuit-breaker initiated by the device, separately for each circuit-breaker pole (if 1-pole tripping is possible)
- Total sum of primary breaking currents
- Sum of the primary breaking currents, separately for each breaker pole
- Hours with open circuit breaker
- Hours under load

The following values are available for each disconnector switch:

- Total number of switching operations of the disconnector switch initiated by the device
- Number of switching operations of the disconnector switch initiated by the device, separately for each switch pole (if 1-pole switching is possible)

10.12 Circuit-Breaker Wear Monitoring

10.12.1 Overview of Functions

The Circuit-breaker wear monitoring function:

- Records the wear of circuit breakers
- Allows maintenance intervals of the CB poles to be carried out when their actual degree of wear makes it necessary
- Sends a warning signal when the wear of a circuit breaker reaches a specified degree
- Allows the supervision of the circuit-breaker make time

Savings on maintenance and servicing costs is one of the main benefits this functionality offers.

10.12.2 Structure of the Function

The Circuit-breaker wear monitoring function can be used in the Circuit breaker function group.

The function offers 4 independent operating stages with different measuring methods:

- **ΣI^x-method stage**
  Sum of tripping current powers
- **2P-method stage**
  2 points method for calculating the remaining switching cycles
- **I²t-method stage**
  Sum of all squared fault-current integrals
- **Supv.CB make time stage**
  Supervision of the circuit-breaker make time

The function is preconfigured by the manufacturer with 1 ΣI^x-method stage. A maximum of 1 ΣI^x-method stage, 1 2P-method stage, 1 I²t-method stage, and 1 Supv.CB make time stage can be operated simultaneously within this function.

The general functionality is available across stages and provides a uniform start criterion for the stages.

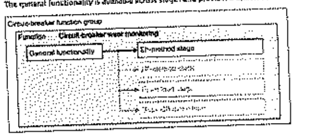

Figure 10-29 Structure/Embedding of the Function

10.12.3 General Functionality

10.12.3.1 Description

Logic

As the wear on the circuit breaker depends on the current amplitude and duration of the actual switching action, including arc deletion, determination of the start and end criteria is important. The following general functionality provides starting and further timing information to the different stages (methods).

The general functionality operates phase-selectively. The following figure shows the logic of the functionality across stages.

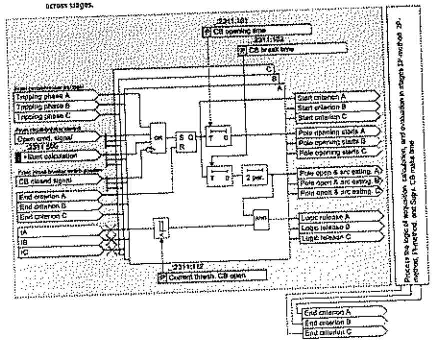

Figure 10-30 Logic Diagram of the Functionality Across Stages of the Circuit-Breaker Wear Monitoring Function

Start Criterion for the Circuit-Breaker Wear Monitoring Function

The Circuit-breaker wear monitoring function starts when any of the following criteria is fulfilled:

- Internal protection function tripping signal from the function block Trip logic is received
- Open command signal from the internal Control function is received.
- Binary input signal >Start calculation is initiated, for example, from external

- Closed position signal of circuit breaker is going
  The signal is derived form the circuit-breaker auxiliary contacts. In this way, opening the circuit-breaker manually is detected.

Logic Input Signals for Stages

As soon as the start criterion has been fulfilled, the timers of the parameterized opening time and break time are started. With the parameter CB opening time, the time when the circuit-breaker pole begins to open is defined. With the parameter CB break time, the time of the pole being open including the arc extinction is defined. The following figure shows the relationship between these circuit-breaker times.

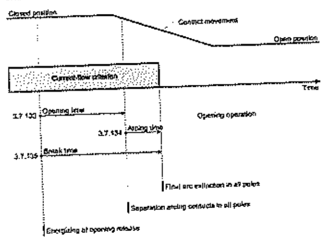

Figure 10-31 Circuit-Breaker Times

In order to prevent an incorrect calculation in case of a circuit-breaker failure, the parameter Current thresh. CB open is used to verify whether the current actually returns to 0 after 2 additional cycles. Fundamental components are used for comparing the threshold values. When the current criterion fulfils the requirement of the phase selective logic release, the calculation and evaluation of the respective methods are initiated.

End Criterion for the Circuit-Breaker Wear Monitoring Function

After calculation and evaluation have been completed, the end criterion of the circuit breaker maintenance is fulfilled. The Circuit-breaker wear monitoring function is ready for a new initiation.

10.12.3.2 Application and Setting Notes

Parameter: CB opening time

- Default setting value (_:2311:101) CB opening time = 0.065 s

You use the CB opening time parameter to define the time span from energizing the shunt release of the circuit breaker until the start of opening of switching poles.

You can find the information on the setting value in the technical data of the used circuit breaker. Also refer to Figure 10-31.

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Parameter: CB break time

- Default setting (_:2311:102) CB break time = 0.080 s

You use the CB break time parameter to define the time span from energizing the shunt release of the circuit breaker to the instant of arc extinction (and switching pole open).
You can find the information on the setting value in the technical data of the used circuit breaker. Also refer to Figure 10-17.

Parameter: CB make time

- Default setting (_:2311:103) CB make time = 0.080 s

With the parameter CB make time, you define the typical time interval between the activation of the closing procedure for the circuit breaker and the point in time when the first current flows.
You can find more information on the setting value in the technical data of the used circuit breaker.

10.12.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:CB opening time		0.001 s to 0.500 s	0.065 s
_:2311:102	General:CB break time		0.001 s to 0.600 s	0.080 s
_:2311:103	General:CB make time		0.001 s to 0.600 s	0.080 s

10.12.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Start calculation	SPS	I

10.12.4 Stage Description ΣI* Method

10.12.4.1 Description

Logic of the Stage

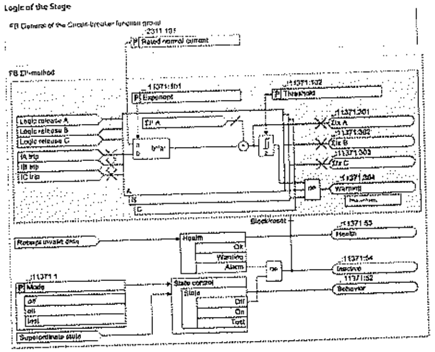

Figure 10-37 Logic of the ΣI*-Method Stage

Determination of the Tripping/Opening Current Value

RMS values of the fundamental components are stored for each phase in a buffer during the time between the start criterion and the pole-opening-starts criterion. With the coming pole-opening-starts criterion, the latest value in the buffer is selected for whose value is above the setting of parameter Current thresh. CB open. The 20 ms prior value is used as tripping/opening current for further calculation.
If no value within the buffer is above the setting value, this circuit-breaker opening affects only the mechanical lifetime of the circuit breaker and is consequently not considered by this method.

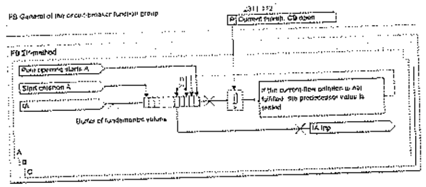

Figure 10-33 Logic of the Determination of the Tripping Current Value

(1) Current flow criterion fulfilled
(2) 20 ms prior value

Calculation of the Wear

If the ΣI*-method stage receives the logic release signal, the determined tripping current is used in the calculation of wear. The calculation results are then added to the existing statistic values of the ΣI* method as follows, with phase A as example.

$$\sum I_A^x = \frac{1}{I_{rated}^x} \sum_{q=1}^{m} I_{A,trip,q}^x$$

Where:

x	Parameter exponent
q	No. of circuit-breaker switching cycle
$I_{A,trip,q}^x$	Tripping/opening current of phase A to the power of x in the qth circuit-breaker operation
I_{rated}^x	Rated normal current to the power of x
$\sum I_A^x$	Statistic value of current phase A calculated with the ΣI* method
m	Total number of switching cycles

The phase-selective ΣI* value is available as statistical value. You can reset or preset the statistics according to the specific application.
To simplify the interpretation of the sum of the tripping current powers, the values are set in relation to the exponentiated rated normal current I_{rated} of the circuit-breaker (see also Setting notes).

Circuit-Breaker Maintenance Warning

If the summated ΣI* value of any phase is greater than the threshold, a phase selective warning signal is generated.

10.12.4.2 Application and Setting Notes

Parameter: Exponent

- Default setting (_:11371:101) Exponent = 2.0

You use the Exponent parameter to specify the exponent for the ΣI* method.
A typical value is the default setting of 2. However, due to practical experiences with individual circuit breakers, slightly different values may be requested.

Parameter: Threshold

- Default setting (_:11371:102) Threshold = 10 000.00

You use the parameter Threshold to define the threshold of the statistic value.
The relation of the tripping current powers to the exponentiated rated normal current I_{rated} allows the limiting value of the ΣI* method to correspond to the maximum number of make-break operations. For a circuit breaker, whose contacts have not yet been worn, the maximum number of make-break operations can be entered directly as limiting value.

10.12.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
ΣIx-method				
_:11371:1	ΣIx-method:Mode		• off • on • test	off
_:11371:101	ΣIx-method:Exponent		1.0 to 3.0	2.0
_:11371:102	ΣIx-method:Threshold		0 to 10000000	10000

10.12.4.4 Information List

No.	Information	Data Class (Type)	Type
ΣIx-method			
_:11371:54	ΣIx-method:Inactive	SPS	O
_:11371:52	ΣIx-method:Behavior	ENS	O
_:11371:53	ΣIx-method:Health	ENS	O
_:11371:301	ΣIx-method:ΣIx A	BCR	O
_:11371:302	ΣIx-method:ΣIx B	BCR	O
_:11371:303	ΣIx-method:ΣIx C	BCR	O
_:11371:304	ΣIx-method:Warning	ACT	O

10.12.5 Stage Description 2P Procedure

10.12.5.1 Description

Logic of the Stage

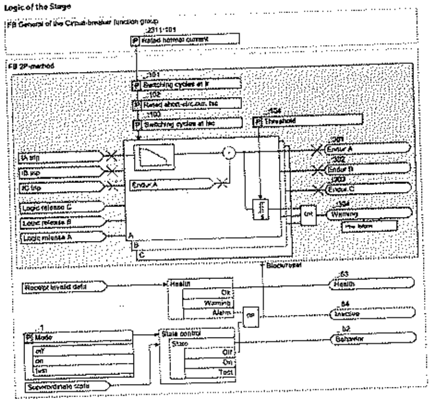

Figure 10-34 Logic of the 2P-Method Stage

Determination of the Tripping/Opening Current Value

For the description to determine the tripping/opening current value, refer to chapter 10.12.4.1 Description.

Calculation of Remaining Switching Cycles

A double-logarithmic diagram provided by the circuit-breaker manufacturer illustrates the relationship of permitted switching cycles and the tripping/opening current, see the following figure. According to the example, this circuit breaker can operate approximately 1000 times at a tripping current of 10 kA.
2 points and their connecting line determine the relationship of switching cycles and tripping current. Point P1 is determined by the number of permitted switching cycles at rated normal current I_{rated}. Point P2 is deter-

mined by the maximum number of switching cycles at rated short-circuit breaking current I_{sc}. The 4 associated values can be configured with the parameters Rated normal current, Switching cycles at Ir, Rated short-circ.cur. Isc, and Switching cycles at Isc.

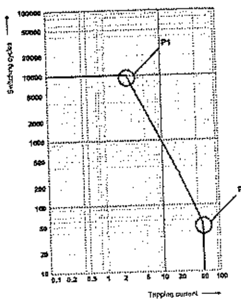

Figure 10-35 Diagram of Switching Cycles for the 2P Method

As shown in the preceding figure, a double-logarithmic diagram, the straight line between P1 and P2 can be expressed by the following exponential function:

$$n = b \cdot \left(\frac{I_{trip}}{I_{rated}}\right)^{m}$$

Where:

I_{trip}	Tripping/opening current
I_{rated}	Rated normal current
m	Slope coefficient
b	Switching cycles at rated normal current
n	Number of switching cycles

The general line equation for the double logarithmic representation can be derived from the exponential function and leads to the coefficients b and m

NOTE

Since a slope coefficient of m < −4 is technically irrelevant, but could theoretically be the result of incorrect settings, the slope coefficient is limited to −4. If a coefficient is smaller than −4, the exponential function in the switching-cycles diagram is deactivated. The maximum number of switching cycles with I_{sc} is used instead as the calculation result for the current number of switching cycles, as the dashed line with m = −4.48 shows in following figure.

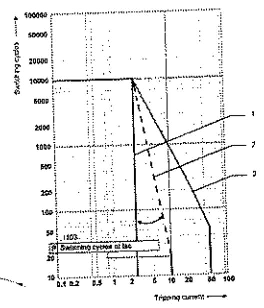

Figure 10-36 Value Limitation of Slope Coefficient

(1) Applied function from m = −4

(2) Parameterized function with m = −4.48

(3) Parameterized function with m = −1.77

If the 2P-method stage receives the logic release signal, the current number of used up switching cycles (in relation to the number of switching cycles at rated normal current) is calculated based on the determined tripping current. This value is subtracted from the remaining lifetime (switching cycles). The remaining lifetime is available as statistic value. For better understanding, refer to the example below.

You can reset or preset the statistical values according to the specific application. The reset operation changes the statistic values to 0, and not to their default values of 10 000.

The statistic value of the residual switching cycles is calculated according to the following formula:

$$Endur_i = Endur_{i-1} - \frac{n_{rated}}{n_{trip}}$$

Where:

i	No. of latest circuit-breaker switching cycle
$Endur_i$	Residual switching cycles with rated normal current, after the ith switching cycle
n_{rated}	Overall permissible switching cycles at rated normal current
n_{trip}	Overall permissible switching cycles at tripping current I_{trip}
n_{rated}/n_{trip}	Lost switching cycles referring to rated normal current

EXAMPLE

For calculating the residual switching cycles of a circuit breaker, the following is assumed:

P1 (2.5 kA, 10 000)

P2 (50.0 kA, 50)

The circuit breaker has made 100 opening operations with rated normal current, 2 tripping operations with rated short-circuit breaking current, and 3 tripping operations with 10 kA tripping current. Then, the residual switching cycles with rated normal current are:

$$Endurance = n_{rated} - \left(100 \cdot \frac{n_{rated}}{n_{rated}}\right) - \left(2 \cdot \frac{n_{rated}}{n_{ISC}}\right) - \left(3 \cdot \frac{n_{rated}}{n_{10kA}}\right)$$

$$= 10000 - \left(100 \cdot \frac{10000}{10000}\right) - \left(2 \cdot \frac{10000}{50}\right) - \left(3 \cdot \frac{10000}{981}\right) = 9465$$

There are still 9465 possible break operations at rated normal current.

Circuit-Breaker Maintenance Warning

If the residual switching cycles of any phase lie below the threshold, a phase-selective warning signal is generated.

10.12.5.2 Application and Setting Notes

Parameter: Switching cycles at Ir

- Default setting (_:101) Switching cycles at Ir = 10 000

You use the Switching cycles at Ir parameter to define the number of permitted switching cycles at rated normal current.

You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: Rated short-circ.cur. Isc

- Default setting (_:102) Rated short-circ.cur. Isc = 25 000 A

You use the Rated short-circ.cur. Isc parameter to define the rated short-circuit breaking current.

You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: Switching cycles at Isc

- Default setting (_:103) Switching cycles at Isc = 50

You use the Switching cycles at Isc parameter to define the number of permitted switching cycles at rated short-circuit breaking current.

You can find the information on the setting value in the technical data of the used circuit breaker.

Parameter: Threshold

- Default setting (_:104) Threshold = 1000

You use the Threshold parameter to define the threshold of residual switching cycles with rated normal current. A warning signal is generated when the statistic is less than the Threshold.

Example

Here is an example that shows you how to set the Threshold parameter. Assuming a circuit breaker with the same technical data as provided in the example for residual switching cycles, 50 breaking operations with rated short-circuit breaking current are permitted.

A warning signal should be issued when the number of residual breaking operations with rated short-circuit breaking current is less than 3. For this condition, you set the Threshold value based on the following calculation:

$$3 \cdot \frac{n_{rated}}{n_{ISC}} = 3 \cdot \frac{10000}{50} = 600$$

10.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
2P-method				
_:1	2P-method:Mode		• off • on • test	off
_:101	2P-method:Switching cycles at Ir		100 to 1000000	10000
_:102	2P-method:Rated short circ.cur. Isc		10 A to 100000 A	25000 A
_:103	2P-method:Switching cycles at Isc		1 to 1000	50
_:104	2P-method:Threshold		0 to 10000000	100

10.12.5.4 Information List

No.	Information	Data Class (Type)	Type
2P-method			
_:54	2P-method:Inactive	SPS	O
_:52	2P-method:Behavior	ENS	O
_:53	2P-method:Health	ENS	O
_:301	2P-method:Endur.A	INS	O
_:302	2P-method:Endur.B	INS	O
_:303	2P-method:Endur.C	INS	O
_:304	2P-method:Warning	ACT	O

10.12.6 Stage Description I²t Method

10.12.6.1 Description

Logic of the Stage

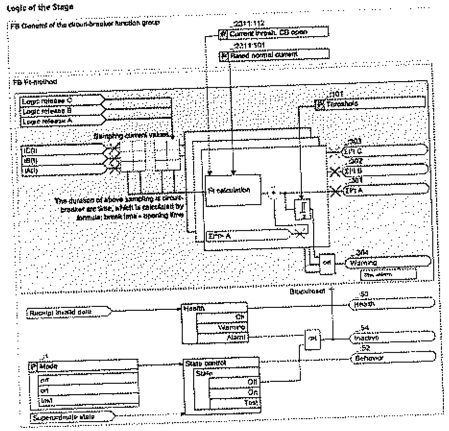

Figure 10-37 Logic of the I²t Method Stage

Calculation of the Wear

The I²t method evaluates the wear of a circuit breaker based the sampled measuring values of the phase currents during the arc time. The duration of the arc time is defined by the difference between the 2 settings of parameters CB break time and CB opening time (see also Figure 10-37). The stage determines the ending point of the arc time by searching backward the zero-crossing point of the phase currents after it receives the logic release signal. Then, the squared fault currents during the arc time are integrated phase-

selectively. The integrals are referred to the squared rated normal current of the circuit breaker as shown in the following formula, with phase A as example.

$$I^2t_A = \frac{1}{I^2_{rated}} \int_{Start\ arc\ time}^{End\ arc\ time} i^2_A(t)dt$$

Where:

I_{rated}	Rated normal current
$i_A(t)$	Sampled measured current value of phase A

The calculated squared tripping current integrals are added to the existing statistic values. You can reset or preset the statistic value according to the specific application.

Circuit-Breaker Maintenance Warning

If the statistic value of any phase lies above the threshold, a phase-selective warning signal is generated.

10.12.6.2 Application and Setting Notes

Parameter: Threshold

- Default setting (_:101) Threshold = 10 000.00 I/Ir²s

You use the Threshold parameter to specify the maximum permitted integral of squared sampled measured values of the phase currents.

10.12.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I2t-method				
_:1	I2t-method:Mode		• off • on • test	off
_:101	I2t-method:Threshold		0.00 I/Ir²s to 21400000.00 I/Ir²s	10000.00 I/Ir²s

10.12.6.4 Information List

No.	Information	Data Class (Type)	Type
I2t-method			
_:54	I2t-method:Inactive	SPS	O
_:52	I2t-method:Behavior	ENS	O
_:53	I2t-method:Health	ENS	O
_:301	I2t-method:ΣI²t A	BCR	O
_:302	I2t-method:ΣI²t B	BCR	O
_:303	I2t-method:ΣI²t C	BCR	O
_:304	I2t-method:Warning	ACT	O

10.12.7 Stage Description Supervision CB Make Time

10.12.7.1 Description

Logic of the Stage

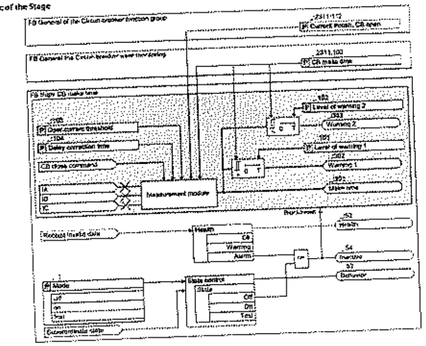

Figure 10-38 Logic of the Supv.CB Make Time Stage

Operating Mode

The stage for the supervision of the circuit breaker make time calculates the time between the circuit breaker closing command and the point in time when the current from at least one phase exceeds the Open. current threshold. If this threshold has not been exceeded after 2.5 times the value of the parameter CB make time, the measurement is canceled and the output value Make time is set to 0 and marked with the quality invalid.

If at least one phase of the current has exceeded the parameter Open. current threshold or the parameter Current thresh. CB open at the time of the circuit-breaker closing command, the measurement is canceled and the output value Make time is marked with the quality invalid.

You can define 2 independent thresholds for the supervision of the measured make time. When these thresholds are exceeded, the corresponding outputs Warning 1 and Warning 2 are activated for 100 ms. These can be routed in the log.

10.12.7.2 Application and Setting Notes

Parameter: Level of warning 1

- Default setting (_:101) Level of warning 1 = 5 %

With the parameter Level of warning 1, you define the percentage the measured value is allowed to exceed the parameter CB make time at the output Make time, before the output Warning 1 is set. The output Warning 1 then drops out after 100 ms.

Parameter: Level of warning 2

- Default setting (_:102) Level of warning 2 = 10 %

With the parameter Level of warning 2, you define the percentage the measured value is allowed to exceed the parameter CB make time at the output Make time, before the output Warning 2 is set. The output Warning 2 then drops out after 100 ms.

Parameter: Oper.current threshold

- Default setting (_:103) Oper.current threshold = 0.100 A

With the parameter Oper.current threshold, you define the current threshold. If the measured value exceeds this threshold, the measured value is detected as flowing operating current. As soon as an operating current flows, the end of the time interval Make time is detected.

Parameter: Delay correction time

- Default setting (_:104) Delay correction time = 0.000 s

With the parameter Delay correction time, you define a correction value which will be subtracted from the Make time during calculation. This allows you to compensate delays caused by the system, for example, relay residual times, if necessary.

10.12.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv.CB make time				
_:1	Supv.CB make time:Mode		• off • on • test	off
_:101	Supv.CB make time:Level of warning 1		1 % to 100 %	5 %
_:102	Supv.CB make time:Level of warning 2		1 % to 100 %	10 %
_:103	Supv.CB make time:Oper.current threshold	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
_:104	Supv.CB make time:Delay correction time		-0.050 s to 0.050 s	0.000 s

10.12.7.4 Information List

No.	Information	Data Class (Type)	Type
Supv.CB make time			
_:54	Supv.CB make time:Inactive	SPS	O
_:52	Supv.CB make time:Behavior	ENS	O
_:53	Supv.CB make time:Health	ENS	O
_:301	Supv.CB make time:Make time	MV	O
_:302	Supv.CB make time:Warning 1	SPS	O
_:303	Supv.CB make time:Warning 2	SPS	O

11 Functional Tests

11.1 General Notes

Various tests have to be performed for commissioning to warrant the correct function of the device.

For tests using secondary test equipment, make sure that no other measurands are linked in and trip and close commands to the circuit breakers are interrupted, unless otherwise indicated.

Secondary tests can never replace primary tests because they cannot include connection faults. They provide a theoretical check of the setting values only.

Primary tests may be done only by qualified personnel who are familiar with the commissioning of protection systems, with the operation of the system, and with safety regulations and provisions (switching, grounding, etc.).

Switching operations also have to be performed for the commissioning. The described tests require that these be capable of being performed safely. They were not conceived for operational checks.

11.2 Direction Test of the Phase Quantities (Current and Voltage Connection)

The proper connection of the current and voltage transformer is checked with load current over the line to be protected. For this, the line must be switched on. A load current of at least 0.1 I_{rated} has to flow over the line; it should be ohmic to ohmic inductive. The direction of the load current has to be known. In case of doubt, meshed and ring systems should be unraveled. The line remains switched on the for the duration of the measurements.

The direction can be derived directly from the operational measured value. First make sure that the power measured values correspond to the power direction. Normally, it can be assumed that the forward direction (measuring direction) goes from the busbar toward the line.

Using the power measured values at the device or DIGSI 5, make sure that it corresponds to the power direction:

- P is positive if the active power flows in the line or protected object.
- P is negative if the active power flows to the busbar or out of the protected object.
- Q is positive if the inductive reactive power flows in the line or protected object.
- Q is negative if the inductive reactive power flows to the busbar or out of the protected object.

If the power measured values have a different sign than expected, then the power flow is opposite the current-direction definition. This can be the case, for example, at the opposite end of the line. The current-transformer neutral point then points in the direction of the protected object (for example line).

If the values are not as expected, it may be due to a polarity reversal at the voltage connection.

As a final step, switch off the system.

11.3 Direction Test of Ground Quantities for Directional Ground-Fault Functions

11.3.1 Overview

If the CT and VT connections are in the way that the ground quantities (3I0 and V0) are calculated by the device from the phase quantities, then, no additional directional test is required. Testing according to 11.2 Direction Test of the Phase Quantities (Current and Voltage Connection) is sufficient.

If the ground current IN or the ground voltage VN is directly measured via a device input (usually I4 or V4), the correct polarity of the ground current and the ground voltage path must be checked.

> **DANGER**
>
> Live system parts! Capacitive coupled voltages on dead parts!
>
> **Noncompliance with the following measures can lead to death, serious physical injury, or considerable material damage.**
>
> - Primary measures may be performed only on dead and grounded system parts.

11.3.2 Directional Testing for Solid or Resistive-Grounded Systems

Primary Test

The primary test is used for the evaluation of the correct polarity of the transformer connections for the determination of the ground-fault direction.

To generate a zero-sequence voltage V0, the e-n winding of one phase in the voltage-transformer set (for example, phase A) is bypassed, see Figure 11-1. If no connection on the e-n windings of the voltage transformer is provided, the corresponding phase is disconnected on the secondary side, see Figure 11-2. Only the current of the transformer in the phase of which the voltage is missing is transferred via the current circuit. If the line carries resistive-inductive load, the protection is subject to the same conditions as existing during a ground fault in line direction.

For directional testing, the Directional ground-fault protection function (67N) is configured and at least one stage is switched on. The pickup threshold of the stage must be below the load current of the line. If not, the binary input signal (_:2311:501) >Test of direction can be activated to lower the threshold temporarily for testing means without changing the respective parameter.

After switching the line on and off again, you can check the pickup signal of the directional protection stage in the fault log. A forward information must be logged. If no pickup information is logged at all, the 3I0 or V0 threshold is not exceeded.

If a wrong direction is logged, one of the following conditions may have occurred:

- The direction of the load flow is from the line towards the busbar.
- The ground current connection is incorrect.
- The voltage connection is incorrect.

> **NOTE**
>
> Siemens recommends not to change parameter settings for the test. However, if parameters were changed for this test, they must be returned to their original state after completing the test!

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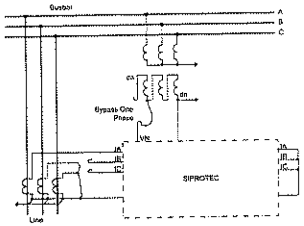

Figure 11-1 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Broken-Delta Connection

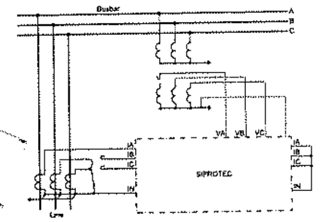

Figure 11-2 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Star Connection

11.3.3 Directional Testing for Isolated or Resonant-Grounded Systems

Primary Test

The primary test is used for the evaluation of the correct polarity of the transformer connections for the determination of the ground-fault direction.

For directional testing, the Directional sensitive ground-fault detection function (67Ns) is configured and a directional stage is switched on. For example, the directional 3I0> stage with cos φ or sin φ measurement. The most reliable test is the one with a primary ground fault. Proceed as follows:

- Isolate the line and ground it on both sides; on the farthest line end it must remain open during the entire test.
- Place a 1-phase ground fault bridge on the line. For overhead lines, this can be done at an arbitrary location, in any case behind the current transformer (as seen from the busbar of the feeder to be tested). For cables, the grounding is done on the farthest end (sealing end).
- Remove the protective grounding from the line.
- Switch on the circuit breaker on the line to be tested.
- Check direction indicator (LED if routed).
- Check the indication (_:302) Ground fault in the ground-fault log or fault log with regard to its direction. The indication (_:302) Ground fault forward must be logged as direction information. If backwards is determined as the direction, either with the current connections or the voltage connections, there is an inversion in the neutral path. For the display unknown, the ground current is probably too low.
- Switch the line off and ground it.

This completes the test.

11.4 Functional Test of Thermal Overload Protection

Secondary Test

For the secondary test for the overload protection, note that all setting parameters refer to primary variables of the protected object. The protection device extracts the current transformer ratio from the power system data and internally performs the adjustments to device-nominal variables. Take these characteristics into account for the test.

- Reset the thermal memory before you repeat the test. This is possible, for instance, via the binary input indication >Reset thermal replica. If the function is reparameterized or is switched off, the thermal replica will also be reset.

Test without Previous Load

- Test the operate time at 1.5 $I_{\text{rated,obj}}$.

In the example, the following power-system data are assumed:

$I_{\text{rated,obj}}$ = 483 A

$I_{\text{rated,transf.,prim}}$ = 750 A

$I_{\text{rated,transf.,sec}}$ = 1 A

The primary test current is 1.5 * 483 A = 724.5 A. This results in a secondary current of 724.5 A * 1 A/750 A = 0.966 A. A secondary current of 0.966 A must therefore be supplied.

- Calculate the operate time with the following formula. Enter only primary variables here.
- Set $I_{\text{precond,start}}$ = 0. The setting parameters reveal the K-factor (for example, 1.1) and the Thermal time constant (for example, 600 s or 10 min).
- Test from the cold state.

$$t = \tau_{th} \cdot \ln \frac{\frac{1}{k^2}\left(\frac{I}{I_{\text{rated,obj}}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{\text{preload}}}{I_{\text{rated,obj}}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{\text{rated,obj}}}\right)^2 - 1} = 600\,s \cdot \ln \frac{\frac{1}{1.1^2}\left(\frac{1.5 I_{\text{rated,obj}}}{I_{\text{rated,obj}}}\right)^2 - 0}{\frac{1}{1.1^2}\left(\frac{1.5 I_{\text{rated,obj}}}{I_{\text{rated,obj}}}\right)^2 - 1} = 600\,s \cdot 0.772 = 463\,s$$

- At a current of 0.966 A supplied on the secondary side, the protection function must trip after 463 s.

Test with Previous Load

- The object rated current ($I_{\text{prim,rated,obj}}$ = $I_{\text{rated,obj}}$) flows at a previous load of 1 (100 %).
- Supply 483 A * 1 A/750 A = 0.644 A in this case.

After a finite time (greater than 5 τ_{th}), the stationary previous load sets in.

K-factor

- If you abruptly increase the supplied secondary current from 0.644 A to 0.966 A (1.5 $I_{\text{rated,obj}}$), the overload protection will trip in the following time:

$$t = \tau_{th} \cdot \ln \frac{\frac{1}{k^2}\left(\frac{I}{I_{\text{rated,obj}}}\right)^2 - \frac{1}{k^2}\left(\frac{I_{\text{preload}}}{I_{\text{rated,obj}}}\right)^2}{\frac{1}{k^2}\left(\frac{I}{I_{\text{rated,obj}}}\right)^2 - 1} = 600\,s \cdot \ln \frac{\frac{1}{1.1^2}\left(\frac{1.5 I_{\text{rated,obj}}}{I_{\text{rated,obj}}}\right)^2 - \frac{1}{1.1^2}\left(\frac{1.0 I_{\text{rated,obj}}}{I_{\text{rated,obj}}}\right)^2}{\frac{1}{1.1^2}\left(\frac{1.5 I_{\text{rated,obj}}}{I_{\text{rated,obj}}}\right)^2 - 1} = 600\,s \cdot 0.184 = 110\,s$$

-

> **NOTE**
> Owing to the relatively large time constants in practice, the tests are carried out with significantly reduced time constants. Reset the original setting value after completing the tests.

11.5 Primary and Secondary Tests of the Circuit-Breaker Failure Protection

Integration of the Protection Function into the Station

The integration of the protection function into the station must be tested in the real-life application. Because of the multitude of possible applications and possible system configurations, the required tests cannot be described here in detail.

> **NOTE**
> Always keep the local conditions, the station plans, and protection plans in mind.

> **NOTE**
> Siemens recommends isolating the circuit breaker of the tested feeder at both ends before starting the tests. Line disconnector switches and busbar disconnector switches must be open so that the circuit breaker can be operated without risk.

General Precautions

> **CAUTION**
> Tests on the local circuit-breaker of the feeder cause a trip command to the output to the adjacent (busbar) circuit breakers.
> **Noncompliance with the following measure can result in minor personal injury or physical damage.**
> - In a first step, interrupt the trip commands to the adjacent (busbar) circuit breakers, for example, by disconnection of the corresponding control voltages.

For testing the circuit breaker failure protection, it must be ensured that the protection (external protection device or device-internal protection functions) cannot operate the circuit breaker. The corresponding trip command must be interrupted.

Although the following list does not claim to be complete, it can also contain points, which have to be ignored in the current application.

Test Modes

The device and the function can be switched to test mode. These test modes support the test of the function in different ways:

Test Modes	Explanation
Device in test mode	This operating mode is relevant for the following tests: 1. Approach of current thresholds in the case of an external start: Supervision of the binary input signals in the case of an external start is disabled. This setting allows a static activation of the starting signals in order to approach the current threshold. 2. Check whether the issued trip commands actuate the corresponding circuit breakers, because the device contacts are also actuated in the device test mode.
CBFP function in test mode (device is NOT in test mode)	This operating mode is important for function tests in which the generated operate indications are still supposed to actuate the binary outputs.

> **NOTE**
> When the function or device is in test mode, all indications are given a test bit.

> **NOTE**
> In the mode Device in test mode, the operate indications generated by the function operate the binary outputs.

The function must also be tested in its normal, switched-on condition.

Consider the following in this case:

- The device contacts are actuated.
- Binary input signal supervision (in the case of an external start) is enabled and blocks the function.
- All indications generated are generated without test bit.

Circuit-Breaker Auxiliary Contacts

When circuit-breaker auxiliary contacts are connected to the device, they make an essential contribution to the reliability of the circuit-breaker failure protection, provided that their settings are set accordingly.

- Make sure that the correct assignment has been checked.

Internal Starting Conditions (Trip Command from Internal Protection Function)

The internal start can be tested by means of tripping a protection function, for example, the main protection function of the device.

- Check the settings for circuit-breaker failure protection. See also chapter 6.39.4 *Application and Setting Notes*.
- For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the Operating manual). It can also be a secondary test current.
- Generate the trip for the protection function. This can be generated within the device by a test sequence (see description in the Operating manual) or by creating corresponding secondary test values.
- The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

External Starting Conditions (Trip Command from External Protection Function)

If external protection devices are also able to start the circuit-breaker failure protection, the external starting conditions require checking.

- Check the settings for circuit-breaker failure protection.
  See also chapter 6.39.4 *Application and Setting Notes*.
- For the circuit-breaker failure protection to be able to pick up, a phase current (see current flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the Operating manual). It can also be a secondary test current.
- Actuate the binary input or inputs to which the start signal and possibly also the release signal for the CBFP function are routed. This can be done in 2 ways:
  – 1) Via internal test sequences
  – 2) By controlling the binary input or inputs via an auxiliary voltage
- Check the start input signal, and if available, check the enable input signal in the spontaneous or fault messages.
- Check the pickup indication in spontaneous or fault indications.
- The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

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Start by Trip Command from the External Protection

- Check the static and – in case of 2-channel operation – also the dynamic supervision of the binary input signals. For this purpose, induce pickup of the supervision and check the supervision indications and the ready signal in the event log buffer.

Start by Trip Command from the External Protection without Current Flow

- If start is possible without current flow: (see Start by trip command from the external protection)

Repetition of the Local Tripping (T1)

- Make sure that the trip-repeat signal controls a 2nd circuit (2nd coil) for switching off the circuit breaker.

Backup Tripping in the Case of a Circuit-Breaker Failure (T2)

For tests in the station, it is important to check that the distribution of trip commands to the adjacent circuit breakers in the case of a circuit breaker failure is correct. The adjacent circuit breakers are all circuit breakers, which must be tripped in order to ensure interruption of the short-circuit current if the feeder circuit-breaker fails. They are therefore the circuit breakers of all feeders which feed the busbar or busbar section to which the feeder with the fault is connected.

A general detailed test guide cannot be specified because the layout of the adjacent circuit-breakers depends largely on the system topology.

- With multiple busbars, the trip distribution logic for the adjacent circuit breakers must be checked. The test has to check for every busbar section that, in case of a failure of the feeder circuit-breaker under observation, only those circuit-breakers which are connected to the same busbar section are tripped.

Backup Tripping on Circuit-Breaker Failure (T2), Tripping of the Opposite End

If the trip command of the circuit-breaker failure protection must also trip the circuit-breaker at the opposite end of the tested feeder, the communication channel for this remote trip has to be tested as well.

- It is practical to test the communication channel for the remote trip while transmitting other signals in accordance with 11.15.1 Checking the Protection-Data Communication.

Termination

- All temporary measures taken for testing must be undone, such as special switch positions, interrupted trip commands, changes to setting values, or individually switched off protection functions.

11.6 Circuit-Breaker Test

The Circuit-breaker test function enables you to easily perform a complete test of the trip circuit, the closing circuit, and the circuit breaker. For this, the circuit-breaker test carries out an automatic opening and closing cycle of the circuit breaker during operation.

NOTE

If the auxiliary contacts are not connected, a circuit breaker that has been opened may be permanently closed.

The following test program is available for you to carry out the circuit-breaker test.

No.	Test Program
1	3-phase open/closed cycle

Structure of the Function

The Circuit-breaker test function is used in protection function groups for circuit breakers.

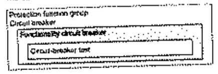

Figure 11-3 Embedding of the Function

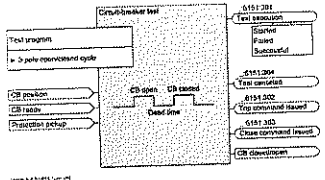

Figure 11-4 Structure of the Function

Test Procedure

The following conditions must be satisfied before the circuit-breaker test can start:

- If a circuit-breaker auxiliary contact signals the position of the breaker pole to the device via the Position binary input, the test cycle is not initiated unless the circuit breaker is closed. If the circuit-breaker auxiliary contact has not been routed, you must ensure that the circuit breaker is closed.
- The circuit breaker must be ready for an open-closed-open cycle (indication >Ready).
- A protection function must not have been picked up in the circuit-breaker protection function group responsible for the circuit breaker.

Figure 11-5 shows the progression over time of an open-close test cycle.

If a circuit-breaker auxiliary contact is connected, the function waits for the indication circuit breaker Position = open after the trip command is generated. When the indication Position = open is received, the close command is transmitted after a dead time (parameter (_:6151:101) Dead time). If the feedback from the circuit breaker position is not received within the maximum transmission time (Dead time + 2 · Output time + 5 s), the circuit-breaker test is aborted and considered to be failed. The proper functioning of the circuit breaker is monitored via the feedback on the circuit breaker positions.

If the circuit breaker auxiliary contact is not connected, the trip command is generated for the parameterized output time (parameter (_:4261:101) Output time)). After the dead time (parameter (_:6151:101) Dead time) has elapsed, the close command follows, also for the duration of the parameterized time (Output time). In this case, you must ensure that the circuit breaker is closed.

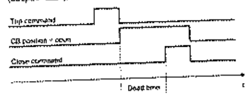

Figure 11-5 Progress over Time of a Circuit-Breaker Test Cycle

The Circuit-breaker test function is used in protection function groups for circuit breakers. If the actual Circuit-breaker functionality has been configured and wired further configuration is not necessary.

- You define the time between the trip command and the close command with the (_:6151:101) Dead time parameter.

NOTE

The circuit breaker test does not perform a synchrocheck even if the synchrocheck has been configured in the protection function groups for circuit breakers. This may cause stability problems in the system during a 3-pole interruption. Therefore, a 3-pole circuit-breaker test should be very short, or not performed at all under load.

You can start the test program as follows:

- Via the device-control panel
- Via DIGSI
- Via control commands, which you can also connect in the CFC

The following figure illustrates operation of the circuit-breaker test in DIGSI.

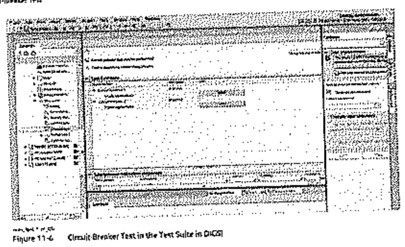

Figure 11-6 Circuit-Breaker Test in the Test Suite in DIGSI

- Select the function in the project tree on the left in the online access.
- Start the desired test program in the upper portion of the middle window.
- The corresponding feedback is displayed in the bottom portion of the middle window. Additional information about the behavior of other functions while the circuit-breaker test is being performed can be read in the operational log.

11.7 Functional Test of the Inrush-Current Detection

General

- For the test, make sure that the test current reflects the typical inrush current.
- Perform the test with transient signals. These can be recorded inrush currents or simulated currents from a transient system model.
- When using synthetic signals, observe the notes on the individual measuring principles.

Harmonic Analysis

- Superimpose on the fundamental component current a test current of double frequency (2nd harmonic) and test the pickup behavior with this.
- Cause a threshold value excess (internal pickup) for one of the protection functions that you want to block.

  or

- Apply a test current with a load current as lead (current step).

The inrush current detection creates a blocking signal.

CWA Process

- Create a test current that has flat ranges of a minimum width of 3 ms simultaneously in all 3 phase currents.

The inrush current detection creates a blocking signal.

11.8 Functional Test of Transient Ground-Fault Protection

General

This function requires the correct polarity of the ground current IN and the neutral-point displacement voltage VN respectively the zero-sequence voltage V0. For the direction test of these quantities, refer to chapter 11.3 Direction Test of Ground Quantities for Directional Ground-Fault Functions.

The function is based on the evaluation of the transient in the zero-sequence system after the ground-fault ignition.

For issuing the signal (_:302) Ground fault, the following 2 conditions must be met:

- There is a transient in the ground quantities.
- The fundamental component of the zero-sequence voltage V0 exceeds the threshold (_:103) V0> threshold value.

The following 2 methods are available for testing of the signal (_:302) Ground fault :

- Replaying real transient ground fault recordings to the device
- Using secondary test equipment which allows to simulate transients ground faults

However, the setting of parameter (_:103) V0> threshold value cannot be tested precisely with the mentioned 2 methods, since this test requires a static V0. An easy way to test the setting is described in the following.

Secondary Test

This test must be carried out by injecting static secondary quantities. The test equipment needs to be configured in a way that it generates zero-sequence current 3I0 and zero-sequence voltage V0, which are injected to the SIPROTEC 5 device. By carrying out a shot, for example, a status change from zero-sequence values of 0 A and 0 V to the values not equal to zero, a transient is generated. The signal (_:302) Ground fault is issued as long as the static zero-sequence voltage of the 2nd state is greater than the set threshold. As amplitude for the secondary 3I0, 100 mA is a suitable value. In this test, the directional result contained in the signal (_:302) Ground fault is not defined and relevant, since the task is to test the setting of parameter (_:103) V0> threshold value only.

For testing the threshold, shots must be carried out with a static V0 slightly below the threshold and slightly above the threshold, for example, to 98 % and 102 % of the threshold value or to a threshold value of -0.2 V and +0.2 V (the greater absolute deviation of the threshold value must be selected).

Consider that the V0 threshold is defined according to the definition of the symmetrical components. A full neutral point displacement voltage VN of 100 V causes V0 = 57.7 V.

Example

- (_:103) V0> threshold value = 15 V
- 2 shots from 0 to V0 = 14.7 V and 3I0 = 100 mA
  No signal (_:302) Ground fault is issued.
- 3 shots from 0 to V0 = 15.3 V and 3I0 = 100 mA
  Signal (_:302) Ground fault is issued

If the test result is not as expected, check the injected static V0 voltage via the operational measurement of the device which contains the zero-sequence components.

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11.9 Functional Test of the Trip-Circuit Supervision

General

- For the test, make sure that the switching threshold of the binary inputs is clearly below half the rated value of the control voltage.

2 Binary Inputs

- Make sure that the binary inputs used are isolated.

1 Binary Input

- Make sure that, in the circuit of the 2nd circuit-breaker auxiliary contact, an equivalent resistance R is connected.
- Observe the dimensioning notes under the section Equivalent resistance R.

11.10 Functional Test for the Phase-Rotation Reversal

- Check the phase sequence (direction of rotating field) at the device terminals. It must correspond to the setting of the Phase sequence parameter.
- The output indication *Phase sequence ABC* or *Phase sequence ACB* displays the determined phase sequence. This must correspond to the phase sequence that was set.
- You can also determine the phase sequence via the **Symmetrical components** measured values. If you obtain negative-sequence system variables (V_2, I_2) and no positive-sequence system variables (V_1, I_1) with symmetrical 3-phase infeed, the setting parameter **Phase sequence** does not correspond to the connection.

11.11 Functional Test for Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Checking the Stator Ground-Fault Protection with the Machine

You have to check whether the protection function and the protection ranges are functioning correctly. The following tests are intended for the unit connection.

You can check the protection range by performing a test with a ground fault at the generator terminals. The ground fault test in the power system enables you to verify the noise suppression of the load resistor.

Checking the Protection Range with a Machine Ground Fault

⚠ DANGER

Touching live parts or reaching into rotating machines will result in death or serious injury.

- Perform primary measures only when the machine is at standstill and the system components are de-energized and grounded.

- Insert a 1-phase to ground jumper into the terminal circuit of the machine.
- Set the **Mode** parameter in the protection stage to **test**. This prevents the trip command from being generated for the stage.
- Start the machine and excite it slowly up to approx. 20 % of the rated machine voltage.
- From the operational measured values, check the plausibility of the zero-sequence voltage V_0 and the input voltage at the connected input.
- Determine the protection range from the pickup voltage.
  The following applies for the protection range S:

$$S = \frac{\frac{V_{N2}}{\sqrt{3}} - V_{0,\text{pickup value}}}{\frac{V_{N2}}{\sqrt{3}}} \cdot 100\ \%$$

Example: Measurement with secondary voltages

V_{NC}: Generator voltage transformed to the transformer secondary side = 100 V

$V_{0,\text{[illegible]}}$: Measured zero sequence voltage at pickup = 5.68 V

S: Resulting protection range = 90 %

- Check the messages in the message buffer. If the **Detection of fault by phase** parameter is set to **yes**, check the display of the phase affected by the fault.
- Shut the machine down and remove the ground fault bridge.
- Set the **Mode** protection stage parameter to **on**.

Checking Disturbance-Voltage Suppression in the Load Resistor with a System Ground Fault

⚠ DANGER

Touching live parts or reaching into rotating machines will result in death or serious injury.

- Perform primary measures only when the machine is at standstill and the system components are de-energized and grounded.

- With the primary system de-energized and grounded, insert a 1-pole ground fault bridge on the high-voltage side of the unit transformer.

⚠ CAUTION

Material can be damaged during the test if there is a neutral-point grounding at the transformer and simultaneously a grounding on the high-voltage side.

- Neutral grounding at the transformer must be interrupted during the test.

- Start the machine and excite it slowly up to 30 % of the rated machine voltage.
- Read the zero-sequence voltage $V_{0,\text{measured value}}$ from the operational measured values.
- Extrapolate the zero-sequence voltage to 100 % of the machine voltage ($V_{0,\text{calc}}$).
- Calculate the safety margin by dividing the calculated fault value by the set threshold value.

If the result is less than 0.5, the safety margin is sufficient. If the fault voltage is lower, you can increase the sensitivity of the protection function.

EXAMPLE:

$V_{0,\text{[illegible]}} = 0.75$ V

$V_{\text{threshold value}} = 5.68$ V

$V_{0,\text{calc}} = 0.75\ \text{V} \cdot 100\ \% / 30\ \% = 2.5$ V

Safety margin = 2.5 V / 5.68 V = 0.44

The calculated safety margin of 0.44 is sufficient because it is below 0.5.

- Shut the machine down and de-excite it. Remove the ground-fault bridge.
- Restore neutral-point grounding if you require grounded operation of the neutral on the high-voltage side of the unit transformer.

When using the function for startup ground fault protection on a busbar connection, carry out the same check as for the unit connection, but only the part Test during machine ground fault.

11.12 Primary and Secondary Testing of the Synchronization Function

Measuring the Circuit-Breaker Closing Time

Under asynchronous system conditions, the circuit-breaker closing time must be measured and set correctly. This achieves an exact parallel switching with a phase angle 0°. If switching occurs only in synchronous system conditions, this section can be skipped.

The closing time can be determined via the following 2 methods:

- 1. By reading from a fault record (recommended method)
- 2. With external timer

1. A simple option for determining the closing time involves reading out the time between the close command and closure of the switch pole via the fault record. The time determined here is the real closing time and not the operating time of the circuit breaker. You do not have to add any further time.

Siemens recommends the following procedure:

- Establish a condition in which the circuit breaker can be closed without hazard.
- If V2 switching through, activate the operating mode `Close cmd. at V1< & V2>` for the synchronization stage by setting to **yes**.
  If V1 is switched through, activate the operating mode `Close cmd. at V1> & V2<`.
- Make sure that the fault recorder is turned on. Via a temporary CFC chart, link the signal **Release close cmd.** of the active synchronization stage to the binary input signal **>Manual start** (of the fault recorder). With the release of closure, a fault record of the parameterized duration is set up (the default setting of 500 ms is more than adequate for this).
- Starting the synchronization stage. The device activates immediately.
- Read the fault record and determine the closing time via SIGRA (see *Figure 11-7*).
  Use the 2 cursors and the time-measuring function for this. Position the first cursor on the rising close command. The occurrence of the second voltage signals the closed power-switching poles. Place the second cursor on the rising second voltage.
- Set the determined time with the `CB make time` parameter. Round off to the next lower adjustable value. Proceed in the same way for all other sync stages.
- Set the parameter `Close cmd. at V1< & V2>` or parameter `Close cmd. at V1< & V2<` back to its original value.
- Delete the CFC chart.

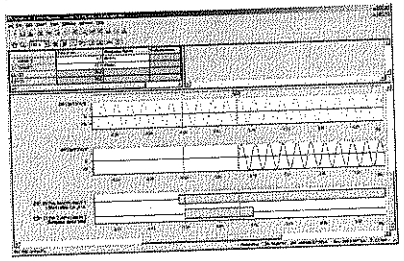

Figure 11-7 Measurement of the Circuit-Breaker Closing Time

2. The arrangement in *Figure 11-8* is suitable for measuring the circuit-breaker operating time with external timer. Set the timer to the range 1 s or a tripping of 1 ms.

Connect the circuit breaker manually. The timer is started simultaneously by this. After the poles of the circuit breaker close, the voltage $V_{...}$ appears. The timer is then stopped.

If the timer is not stopped owing to an unfavorable closing moment, repeat the attempt.

Siemens recommends calculating the average value from several (3 to 5) successful switching attempts.

NOTE

Add the command output time of the protected device to measured time. This exclusively depends in good approximation on the binary output used for the close command. You can find the switching times for the different binary outputs in the Technical data. Set the total time with the parameter `CB make time`. Round off to the next lower adjustable value. Proceed in the same way for all other synchronization stages used.

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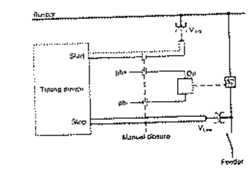

Figure 11-8 Measurement of the Circuit Breaker Closing Time

Checking the Measurement Chain

The measurement chain for the voltage measurement must be checked. As soon as one of the synchronization stages to be used is closed, all the necessary functional measured values are calculated. The synchronization stage, thus, does not have to be started for this check.

Proceed as follows when checking the measurement chain as a primary or secondary test:

a) As primary test

- Establish a synchronous state by closing the circuit breaker, if possible.
- Check the functional measured values within the synchronization function:
  – The delta values must be 0.
  – Check the voltages V1 and V2 for plausible values in comparison with the operational measured values for the voltage.
  – Check the frequencies f1 and f2 for plausible values in comparison with the operational measured value for the frequency.

b) As secondary test

- Establish a synchronous state by applying synchronous voltage values at both measuring points.
- Check the functional measured values within the synchronization function:
  - The delta values must be 0.
  – Check the voltages V1 and V2 for plausible values in comparison with the operational measured values for the voltage.
  - Check the frequencies f1 and f2 for plausible values in comparison with the operational measured value for the frequency.

Blind Switching Attempts when Used in Machines

Perform blind switching attempts when using the function in machines.

Requirement:

- You have checked the setting values again.
- The circuit breaker is switched off. The close command for the circuit breaker is interrupted (disconnecting the close command). The system voltage is switched through for the measurement.

a) Attempt with asynchronous systems:

- Via manual control set the generator to a speed slightly below the permitted frequency difference according to the setting values `Max. frequency diff. f2>f1` and `Max. frequency diff. f2<f1`. The generator is excited to line voltage. You can read out the values in the operational measured values.

- Start the synchronization stage, for example, externally with binary input signal or via the integrated controller. You can use a synchroscope to trigger the start at synchronism, that is, at 12 hours. The duration until the close command then corresponds to a cycle with the duration 1/Δf. At a frequency difference of 0.1 Hz, the duration is thus 10 s.
- Insofar as permissible, perform the attempt several times for asynchronous switching and subsynchronous switching.
- The switching performance can be checked with an external recorder or the integrated fault-recording function. You have to start the fault recording explicitly.
- You can repeat the blind switching attempts at the limits of the permissible voltage difference.

b) Attempt with synchronous systems:

- Start the synchronization stage, for example, externally with binary input signal or via the integrated controller.
- Check the proper release for activation with the message log or via a fault record. You have to start the fault recording explicitly. All activating conditions have to be fulfilled within the time `Delay close command`.

If you observe the change between synchronous and asynchronous operation, raise the changeover threshold `f-threshold ASYN<->SYN` slightly.

c) Attempt with synchrocheck:

- If you use this function in conjunction with the manual synchronization, check the proper release for closure.
- Synchronize the generator manually. Start the synchronization stage externally via a binary input. Check the proper release for closure with the indication log or via the fault record. You have to start the fault recording explicitly.

11.13 Testing the Negative-Sequence Current

When testing, keep in mind that the measured values are standardized. In the setting $I_{2}/I_{rated,obj}$ they are standardized to the rated current of the protected object. The conversion to secondary transformer values is accomplished in the device.

EXAMPLE:

The threshold value is set to 10 % of the protected object

Transformer: 100 A/1 A

Rated current of the protected object: 80 A

Action Steps

- At a setting of 10 %, the primary negative-sequence current is 80 A • 10 %/100 % = 8 A.

For a current transformer ratio of 100, test with a secondary current of 0.08 A.

- With a transformer of 100 A/5 A, the test current is higher by the factor 5. Test with 0.4 A. The pickup value is at 1.1 • 0.4 A = 0.44 A.
- If deviations occur during the testing, you must check whether the power system data were entered correctly.

NOTE

Keep in mind that the function works starting from the set minimum current.

11.14 Reverse Power Protection

11.14.1 Secondary Test

When performing the secondary test, note that the setting value for the reverse power refers to the machine variables. Due to the mismatching of the current transformer, you must check with reduced currents. You can deduce the reduction from the ratio $I_{rated,generator}/I_{rated,CT}$. Check the reverse-power protection at rated voltage. If the voltage transformer is not adjusted to the rated generator voltage, correct the secondary voltage, too. Use the following ratio:

$V_{rated,generator}/V_{rated,VT}$

11.14.2 Primary Test

For measurements on the protection current transformers and with sensitive setting of the reverse-power protection, Siemens recommends determining the reverse power and the angle-correction values. Regardless of the generator excitation, that is regardless of the reactive power Q, the reverse power P at a pure active power is constant. The resulting characteristic curve is a straight line that runs parallel to the Q axis. Due to possible angle errors of current transformers and voltage transformers, the protection device does not measure a constant active power. The current flowing at this time, which can be assumed as being proportional to the reactive power, has a substantial influence.

The deviations are determined with 3 measurements and the correcting quantity φ_{corr} is determined from the results.

To calculate the correction angle, enter the active power and reactive power measured with the device in the following table.

Use the functional measured values `P1avg` and `Q1avg` (type averaged).

Table 11-1 Value Table for Angle Correction

State	Reverse Power	Reactive Power
Reactive power near zero	P_0 =	Q_0 =
Overexcited	P_1 =	Q_1 =
Underexcited	P_2 =	Q_2 =

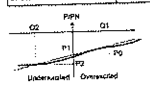

Figure 11-9 Determining the Correction Angle φ_{corr}

CAUTION

Be careful if you operate the turbine without a certain minimum steam flow (cooling effect).

Operating the turbine without a certain minimum steam flow (cooling effect) can overheat the turbine blades!

- The consumption of reverse power for a turbo generator set is only allowed for a short time!

CAUTION

If the generator is underexcited, there is the risk of an out-of-step condition!

Non-observance of the following measures can result in minor personal injury or material damage.

- The following measures prevent the risk of an out-of-step condition.

- Regulate the driving power to 0 by closing the control valves. The generator draws its reverse power from the electrical power system.
- Change the excitation until the reactive power Q = 0. As a control measurement, read the active power P_0 and the reactive power Q_0 with the sign, and enter the values in Table 11-1.
- Increase the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (overexcited).
  Read the reverse power P_1 with the sign (negative) and the reactive power Q_1 with the sign (positive) in the functional measured values and note these 2 values in the values table.
- Reduce the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (underexcited).
  Read the reverse power P_2 with the sign (negative) and the reactive power Q_2 with the sign (negative) in the functional measured values and note these 2 values in the values table.
- Run the generator again at no-load excitation and select the desired operating state.
- With the measured value pairs (P_1, Q_1 and P_2, Q_2), calculate the correction angle φ_{corr} with the following formula:

$$\varphi_{corr} = \arctan \frac{P_1 - P_2}{Q_1 - Q_2}$$

NOTE

Insert the power values with the signs that you read previously.

- Enter this angle φ_{corr} with the same sign as the new correction angle (parameter `(_:2311:101) Angle correction`).

Setting value `(_:2311:101) Angle correction` = φ_{corr}

- You can determine the pickup value of the reverse-power protection from the measured values P1 and P2.

Use the following formula: $P_{pickup} = (P_1+P_2)/4$

Set the value as pickup value: Parameter `(_:1991:3) Threshold` = P_{pickup}

Check of the Reverse-Power Protection

With a generator that is connected to the power system, the reverse power results from closing the control valves or from closing the quick stop.

- In both cases, check the consumed active power (reverse power). The values could be leaving.
- Repeat the reverse power measurement to confirm that the settings are correct.
- To check the efficiency of the reverse power protection on the basis of the indications, use the parameter `(_:1991:1) Mode` to switch the reverse power protection to `test`.

Proceed as follows:

- Start the generator and synchronize it with the power system.
- Close the control valves.
- From the functional measured value, take the reverse power that was measured by the protection device as the active power. Use 50 % of the functional measured value as setting value for the reverse-power protection.
- Increase the driving power up to normal operation.
- Check the quick-stop criterion.
  Proceed as follows:

NOTE

Make sure that the binary input `>Stop valve closed` is properly routed. The quick-stop criterion (the pressure-operated switch or the limit switch on the quick-stop valve) must control this binary input.

- Close the quick-stop valve.
- From the functional measured value `P1avg`, take the reverse power that was measured by the protection device as the active power.
- If – contrary to expectations – this value is smaller than the reverse power when the control valves are closed, take 50 % of this value as the setting value for the reverse-power protection.
- Shut down the machine by activating the reverse-power protection. Set the parameter `(_:1991:1) Mode` to `on`.

11.15 Functional Test Protection Communication

11.15.1 Checking the Protection-Data Communication

Checking the Protection-Data Communication

If the devices are connected to one another via the protection interface and switched on, they contact each other automatically. If, for example, device 1 recognizes device 2, the successful connection is indicated (see next figure). Accordingly, each device signals to all devices that a protection-data communication is available.

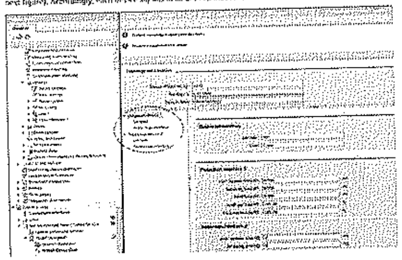

Figure 11-10 Connection Establishment in DIGSI 5

Proper communication of the devices among each other can be supervised during operation.

- Check the connections for each protection interface in DIGSI 5.

If a connection is successfully established, the field Status of topo recog. shows the indication *valid* in DIGSI 5 (see Figure 11-10).

If 2 devices are parameterized incorrectly, the Status of topo recog. field shows the indication *invalid* (see Figure 11-10).

In Figure 11-11 there is no protection-data communication between device 1 and device 2, that is, the protection interfaces 1 and 2 of device 1 do not receive data. The transmission of protection data is interrupted and differential protection is ineffective. One reason for this can be a remote control with DIGSI via the protection interface. In this case, the protection connection is interrupted and the connection is used exclusively for DIGSI.

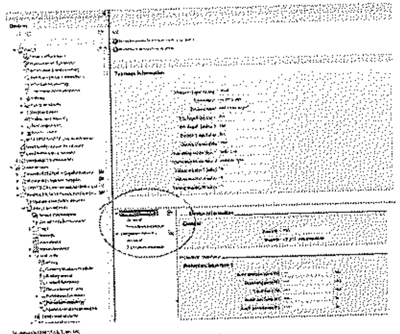

Figure 11-11 Protection-Data CommunicationDeactivated

11.15.2 Directional Test

In the case of protection interfaces of type 1 and type 2, the complex phasors of the voltage and current measuring point are exchanged between devices of one communication topology in order to be able to carry out a directional test during commissioning, for example. DIGSI 5 depicts this in the form of a phasor diagram. You can only route the measuring point to the protection interface. For 1 1/2 circuit breaker layouts, a measuring point can therefore be transferred and checked optionally. You can also check and test the 2nd measuring point by rerouting. Furthermore, communication with DIGSI 5 can take place via the protection interface to other devices of the constellation. For this purpose, the protection-interface connection is interrupted and DIGSI 5 uses this connection for communication with the remote device.

- After completing the remote connection by DIGSI 5, the system switches back over to protection communication.

11.16 Functional Test for Overexcitation Protection

Secondary Test

> **NOTE**
>
> While performing the secondary test, ensure that the data of the protected object refer to the protection function.

This means that a mismatch between the voltage transformer and the protected object will be corrected automatically. For instance, when applying the secondary rated voltage and the rated frequency, this must not result in a V/f value of 1.

The mismatch of the voltage transformer must be taken into consideration when selecting the test voltage. Multiply the secondary test voltage with the following 'k' factor.

$$k = \frac{V_{rated,obj.}}{V_{rated,transf.}}$$

Example

$V_{rated,obj.}$ = 110 kV; $V_{rated,transf.}$ = 100 kV

It follows from the above that k = 1.1. For example, when verifying the nominal conditions if the secondary rated voltage is 100 V, a voltage of 1.1 * 100 V = 110 V must be supplied. The measured value of the function Measured value V/f must display 1.0000.

> **NOTE**
>
> When checking the dependent stage, ensure it is associated with a thermal replica. When repeating a test, always reset the replica, using the binary input indication >Reset therm. replica (_:13591:501).

Primary Test

The plausibility check between instantaneous overexcitation and the displayed operational measured value is used to verify the functionality of overexcitation.

Instantaneous overexcitation is a result of the following function:

$$\frac{V}{f} \cdot \frac{f_{rated}}{V_{rated}}$$

where:

V	Instantaneous voltage
V_{rated}	Primary rated voltage of the protected object
f	Instantaneous frequency in f
f_{rated}	Rated frequency

11.17 Functional Test Differential Protection for Capacitor Banks

11.17.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following chapter 11.17.2 Primary Tests, because they cannot include connection faults.

Secondary tests are used to check the following:

- Checking the setting values
- Proper reaction of the protection function
- Engineering (for example, routing the respective logic signals, display images with measured values, logics in CFC, and much more)

If you want to perform secondary tests, observe the following instructions.

> **NOTE**
>
> For tests with secondary test equipment, ensure that no other measurands are connected and the trip commands to the circuit breakers are interrupted, otherwise, the circuit breakers could be activated.

Perform the tests with the current setting values for the device. If these values are not (yet) present, check with the default values.

> **NOTE**
>
> The measuring accuracy to be attained depends on the electrical data of the test sources. The accuracies stated in the Technical Data can be expected only if the reference conditions stipulated in VDE 0435/part 303 and IEC 60255 are ensured and precision instruments are used. The stated tolerances refer to the default data for the protected objects. If the rated current of the protected object in relation to the rated current of the current transformer deviates considerably from the rated current of the device, you must assume higher response tolerances.

For differential protection, you can check each side separately. This corresponds to the simulation of a fault supplied from one side. If a side has several measuring points, the measuring inputs not included in the test carry no current. The pickup value is tested by increasing the test current slowly.

> **NOTE**
>
> Tests of currents via quadruple device-rated current (for a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find more information in chapter 12.2# Differential Protection for Capacitor Banks. Interrupt testing to allow cool-down!

The set pickup values refer to symmetrical 3-phase current in the case of 3-phase protected objects.

If you are testing parameter-set during operation, you must ensure that the setting value for the differential protection refers to the rated current of the protected object.

If you wish to check the characteristic curve, Siemens recommends using the standard testing programs of digital test equipment. For the manual checking of points on the characteristic curve, feed in a through-flowing current which corresponds to a current value on the stabilization axis. Then change the phase angle of the test current on one side, so that the necessary differential current is achieved. Check a value with a tolerance of 5 % above and below the point on the characteristic curve which is to be tested.

For capacitor banks, the actual pickup values for 2-phase testing also depend on the vector group of the capacitor bank.

To obtain the actual pickup value, multiply the setting value by a vector-group factor k_{VG} according to the following formula:

$$\frac{I_{rated,transf.}}{I_{rated,transf.,pdiff}} \cdot k_{VG}$$

The following table shows this factor k_{VG} in dependence of the vector group and the fault type.

Table 11-2 Correction Factor k_{VG} for the Vector Group (SG) and Fault Type

Fault Type	Reference Winding (High Voltage)	Even SG Number (0, 2, 4, 6, 8, 10)	Odd SG Number (1, 3, 5, 7, 9, 11)
3-phase	1	1	1
2-phase	1	1	√3/2 = 0.866
1 phase with I_0 elimination	3/2 = 1.5	3/2 = 1.5	√3 = 1.73
1-phase without I_0 elimination	1	1	3/(1+√3) = 1.1

11.17.2 Primary Tests

Restricted primary testing is possible for capacitor-bank applications. A wiring fault in the connection to the system could be a possible cause of the fault. With the system at a standstill, you can apply a test current of approx. 10 % to 20 % of the rated current directly to the transformer terminals and connected transformer with a primary testing device. Simulate a load (through-flowing current). The differential current must be 0 and the restraint current is the current which is fed in.

To rule out overfunction on initial switch-on, for example, due to the incorrect installation of a transformer, Siemens recommends switching the differential protection to test mode. The protection function operates, but does not issue a trip command. With the protection measurement values in the fault log, check the differential and the restraint current. The differential current must be 0 and the restraint current must correspond to the actual capacitor current.

If the differential protection is functioning correctly, switch the protection function ON.

> **NOTE**
>
> If the differential protection is disabled (for example, function in test mode), an overcurrent protection must be active as short-circuit protection (without delay and set via the starting current).

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12 Technical Data

12.1 General Device Data

12.1.1 Analog Inputs

Current Inputs

All current, voltage, and power data are specified as RMS values.			
Rated frequency f_{rated}	50 Hz, 60 Hz		
Protection-class current transformers	Rated current I_{rated}	Measuring range of the modular devices	Measuring range of the non-modular devices
	5 A	0 A to 500 A	0 A to 250 A
	1 A	0 A to 100 A	0 A to 50 A
Instrument transformers	5 A	0 A to 8 A	0 A to 8 A
	1 A	0 A to 1.6 A	0 A to 1.6 A
Power consumption per current circuit at rated current	Approx. 0.1 VA		
Thermal rating (protection and instrument transformers)	500 A for 1 s		
	150 A for 10 s		
	20 A continuously		
	25 A for 3 min		
	30 A for 2 min		
Dynamic load-carrying capacity	1250 A one half wave		

Voltage Input

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
Input and output modules	IO202/IO208/IO211/IO214	IO215
Measuring range	0 V to 200 V	0 V to 7.07 V
Input impedance	< 0.1 VA	< 0.01 VA
Thermal rating	230 V continuously	20 V continuously

Measuring-Transducer Inputs (via Module ANAI-CA-4EL)

Connector type	8-pin multiple contact strip
Differential current input channels	4
Measuring range	DC -24 mA to +24 mA
Fault	< 0.5 % of measuring range
Input impedance	140 Ω
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 20 V
Galvanic separation from ground/housing	DC 700 V
Permissible overload	DC 100 mA continuously
Measurement repetition	200 ms

Measuring-Transducer Inputs (via Module ARC-CD-3FO)

Connector type	AVAGO AFBR 4526Z
Number of transceivers	3

Fiber type	Polymer Optical Fiber (POF) 1 mm
Receiver	
Maximum	-10 dBm ± 2 dBm
Minimum	-40 dBm ± 2 dBm
Spectrum	400 nm to 1100 nm
Attenuation	In the case of plastic optical fibers, you can expect a path attenuation of 0.2 dB/m Additional attenuation comes from the plug and sensor head.
Optical budget [1]	Minimal 25 dB
Analog sampling rate	16 kHz
ADC type	10-bit successive approximation
Transmitter	
Type	LED
Wavelength	λ = 650 nm
Transmit power	Minimum 0 dBm Maximum 2 dBm
Numerical aperture	0.5 [2]
Signal rate connection test	1 pulse per second
Pulse duration connection test	11 µs
Comment: [1] All values in combination with sensors approved by Siemens. [2] Numerical aperture (NA = sin θ (launch angle))	

High-Speed Measuring-Transducer Inputs, Voltage/Current (via IO210, IO212)

NOTE

Current and voltage may not be connected to a measuring-transducer input at the same time; only either current or voltage may be connected. Due to EMC, no line may be connected to an input that is not used (current or voltage).

Use shielded cables.

Table 12-1 High-Speed Measuring-Transducer Inputs, Voltage

Differential voltage input channels	8[17]
Measuring range	DC -10 V to +10 V
Fault	< 0.5 % of the measuring range
Input impedance	48 kΩ
Conversion principle	Delta sigma (16 bit)
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation from ground/housing	DC 3.5 kV
Permissible overload	DC 20 V continuously DC 60 V continuously (IO210 M13 terminal point C9)
Measurement repetition	62.5 µs

Table 12-2 High-Speed Measuring-Transducer Inputs, Current

Differential current input channels	8[18]

[17] The IO212 has 8 high-speed measuring-transducer inputs. They can be used either as a voltage or as a current input.
[18] The IO212 has 8 high-speed measuring-transducer inputs. They can be used either as a voltage or as a current input.

Measuring range	DC -20 mA to +20 mA
Fault	< 0.5 % of the measuring range
Input impedance, current	12 Ω
Conversion principle	Delta-sigma (16 bit)
Permissible potential difference between channels	DC 3.5 kV
Galvanic separation from ground/housing	DC 3.5 kV
Permissible current overload	DC 100 mA continuously
Measurement repetition	62.5 µs

12.1.2 Supply Voltage

Integrated Power Supply			
For modular devices, the following printed circuit-board assemblies have a power supply: PS201 – Power supply of the base module and of the 1st device row PS203 – Voltage supply of 2nd device row CB202 – Plug-in module assembly with integrated power supply, for example, to accommodate communication modules			
Permissible voltage ranges (PS201, PS203, CB202)	DC 19 V to DC 60 V	DC 48 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz	
Auxiliary rated voltage V_H (PS201, PS203, CB202)	DC 24 V/DC 48 V	DC 60 V/DC 110 V/DC 125 V/DC 220 V/DC 250 V or AC 100 V/AC 115 V/AC 230 V, 50 Hz/60 Hz	
Permissible voltage ranges (PS101)	DC 19 V to DC 60 V	DC 48 V to 150 V	DC 88 V to DC 300 V AC 80 V to AC 265 V, 50 Hz/60 Hz
Auxiliary rated voltage V_H (PS101)	DC 24 V/DC 48 V	DC 60 V/DC 110 V/DC 125 V	DC 110 V/DC 125 V/DC 220 V/DC 250 V or AC 100 V/AC 115 V/AC 230 V, 50 Hz/60 Hz
Superimposed alternating voltage, peak-to-peak, IEC 60255-11		≤ 15 % of the DC auxiliary rated voltage (applies only to direct voltage)	
Inrush current		≤ 18 A	
Recommended external protection		Miniature circuit breaker 6 A, characteristic C according to IEC 60898	
Internal fuse			
–	DC 24 V to DC 48 V	DC 60 V to DC 125 V	DC 24 V to DC 48 V AC 100 V to AC 230 V
PS101	4 A inert, AC 250 V, DC 150 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20	
PS201, PS203, CB202	2 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200 or Schurter type SPT 5x20		
Power consumption (life relay active)			
–	DC	AC 230 V/50 Hz	AC 115 V/50 Hz

Integrated Power Supply			
1/3 base module, non-modular Without plug-in modules	7.0 W	16 VA	12.5 VA
1/3 base module, modular Without plug-in modules	13 W	33 VA	24 VA
1/6 expansion module	3 W	6 VA	6 VA
1/6 plug-in module assembly without plug-in modules (modules CB202)	3.5 W	14 VA	7 VA
Plug-in module for base module or plug-in module assembly (for example, communication module)	< 5 W	< 6 VA	< 6 VA
Stored-energy time for auxiliary voltage outage or short circuit, modular devices		For V ≥ DC 24 V ≥ 50 ms For V ≥ DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 50 ms	
Stored energy time for auxiliary voltage outage or short circuit, non-modular devices		For V ≥ DC 24 V ≥ 20 ms For V ≥ DC 60 V/DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 200 ms	

12.1.3 Binary Inputs

Rated voltage range	DC 24 V to 250 V The binary inputs of SIPROTEC 5 are bipolar with the exception of the binary inputs on the IO230 and on the IO231.	
Current consumption, excited	Approx. DC 0.6 mA to 1.8 mA (independent of the operating voltage)	
Power consumption, max.	0.6 VA	
Pickup time	Approx. 3 ms	
Dropout time	Approx. 4 ms	
Switching thresholds	Adjustable with DIGSI 5	
	Range 1 for 24 V, 48 V, and 60 V Operating voltage	V_{low} ≤ DC 10 V V_{high} ≥ DC 19 V
	Range 2 for 110 V and 125 V Operating voltage	V_{low} ≤ DC 44 V V_{high} ≥ DC 88 V
	Range 3 for 220 V and 250 V Operating voltage	V_{low} ≤ DC 88 V V_{high} ≥ DC 176 V
Maximum permitted voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. In order to ensure EMC, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

12.1.4 Relay Outputs

Standard Relay (Type S)

Switching capacity	On: 1000 W/VA Off: 30 VA; 40 W ohmic; 30 W/VA at L/R ≤ 40 ms
AC and DC contact voltage	250 V

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Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	10 A for 1 s (make contact)
Short time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (Output Operating Time) Additional delay of the output medium used	≤ 10 ms, typically 8 ms
Max. rated data of the output contacts in accordance with UL certification	DC 24 V, 8 A, General Purpose DC 48 V, 0.8 A, General Purpose DC 240 V, 0.1 A, General Purpose AC 240 V, 5 A, General Purpose AC 120 V, 1/3 hp AC 250 V, 1/2 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V

Fast Relay (Type F)

Switching capacity	On: 1000 W/VA Off: 30 VA; 40 W ohmic; 30 W/VA at L/R ≤ 40 ms
AC and DC contact voltage	250 V
Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (Output Operating Time) Additional delay of the output medium used	Closing time, typical: 4 ms Opening time, typical: 2 ms ≤ 5 ms
Rated data of the output contacts in accordance with UL certification	AC 120 V, 8.5 A, General Purpose AC 277 V, 6 A, General Purpose AC 277 V, 0.7 hp AC 347 V, 4.5 A, General Purpose B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Supervision	2-channel activation with cyclic testing (only for make contact)

High-Speed Relay with Semiconductor Acceleration (Type HS)

Switching capacity	On/Off: 1000 W/VA
Contact voltage	AC 200 V, DC 250 V
Permissible current per contact (continuous)	5 A

Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A
Switching time OOT (Output Operating Time) Additional delay of the output medium used	Closing time, typical: 0.2 ms Opening time, typical: 6 ms Maximum: ≤ 9 ms
Rated data of the output contacts in accordance with UL certification	B150 Q300

Power Relay (for Direct Control of Motor Switches)

Switching capacity for permanent and periodic operation		
250 V/4.0 A 220 V/4.5 A 110 V/5.0 A 60 V/5.0 A 48 V/5.0 A 24 V/5.0 A	1000 W 1000 W 550 W 300 W 240 W 120 W	In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
Turn on switching power for 30 s, recovery time until switching on again is 15 minutes. For short-term switching operations, an impulse/pause ratio of 3 % must be considered.		
100 V/9.0 A 60 V/10.0 A 48 V/10.0 A 24 V/10.0 A	1000 W 600 W 480 W 240 W	Continuous and inching operation is not permitted. In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
AC and DC contact voltage		250 V
Permissible continuous current per contact		5 A
Permissible current per contact (switching on and holding)		30 A for 1 s
Short-time current across closed contact		250 A for 30 ms
Total permissible current for contacts connected to common potential		5 A
Switching time OOT (Output Operating Time) Additional delay of the output medium used		≤ 16 ms
Rated data of the output contacts in accordance with UL certification		DC 300 V, 10 A, Resistive DC 250 V, 1 hp motor - 30 s ON, 15 min OFF DC 110 V, 3/4 hp motor - 30 s ON, 15 min OFF DC 60 V, 1/2 hp motor - 30 s ON, 15 min OFF DC 48 V, 1/3 hp motor - 30 s ON, 15 min OFF DC 24 V, 1/6 hp motor - 30 s ON, 15 min OFF
Interference suppression capacitors across the contacts		4.7 nF, ± 20 %, AC 250 V
The power relays operate in interlocked mode, that is, only one relay of each switching pair picks up at a time thereby avoiding a power-supply short circuit.		

12.1.5 Design Data

Masses

	Device Size Weight of the Modular Devices				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	4.8 kg	8.1 kg	11.4 kg	14.7 kg	18.0 kg
Surface-mounted device with integrated on-site operation panel	7.8 kg	12.6 kg	17.4 kg	22.2 kg	27.0 kg
Surface-mounted device with detached on-site operation panel	5.1 kg	8.7 kg	12.3 kg	15.9 kg	19.5 kg

	Size	Weight
Detached on-site operation panel	1/3	1.9 kg
Detached on-site operation panel	1/6	1.1 kg

	Device Size Weight of the Non-Modular Devices 7xx82
Type of construction	1/3
Flush-mounting device	3.2 kg
Bracket for non-modular surface-mounting variant	1.9 kg

Dimensions of the Basic and 1/3 Modules

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [20] (in inches)
Flush-mounting device	150 mm x 268 mm x 229 mm (5.91 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	150 mm x 314 mm x 337 mm (5.91 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	150 mm x 314 mm x 230 mm (5.91 x 12.36 x 9.06)

Dimensions of Device Rows

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [20] (in inches)				
Type of construction	1/3	1/2	2/3	5/6	1/1
Flush-mounting device	150 mm x 268 mm x 229 mm (5.91 x 10.55 x 9.02)	225 mm x 268 mm x 229 mm (8.86 x 10.55 x 9.02)	300 mm x 268 mm x 229 mm (11.81 x 10.55 x 9.02)	375 mm x 268 mm x 229 mm (14.76 x 10.55 x 9.02)	450 mm x 268 mm x 229 mm (17.72 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	150 mm x 314 mm x 337 mm (5.91 x 12.36 x 13.27)	225 mm x 314 mm x 337 mm (8.86 x 12.36 x 13.27)	300 mm x 314 mm x 337 mm (11.81 x 12.36 x 13.27)	375 mm x 314 mm x 337 mm (14.76 x 12.36 x 13.27)	450 mm x 314 mm x 337 mm (17.72 x 12.36 x 13.27)

[20] Width and depth rounded to whole numbers in mm
[21] Width and depth rounded to whole numbers in mm

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [20] (in inches)				
Surface-mounted device with detached on-site operation panel	150 mm x 314 mm x 230 mm (5.91 x 12.36 x 9.06)	225 mm x 314 mm x 230 mm (8.86 x 12.36 x 9.06)	300 mm x 314 mm x 230 mm (11.81 x 12.36 x 9.06)	375 mm x 314 mm x 230 mm (14.76 x 12.36 x 9.06)	450 mm x 314 mm x 230 mm (17.72 x 12.36 x 9.06)

Expansion Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth [21] (in inches)
Flush-mounting device	75 mm x 268 mm x 229 mm (2.95 x 10.55 x 9.02)
Surface-mounted device with integrated on-site operation panel	75 mm x 314 mm x 337 mm (2.95 x 12.36 x 13.27)
Surface-mounted device with detached on-site operation panel	75 mm x 314 mm x 230 mm (2.95 x 12.36 x 9.06)

Plug-in Module Dimensions

Type of Construction (Maximum Dimensions)	Width x Height x Depth (in inches)
USART-Ax-xEL, ETH-Bx-xEL	61 mm x 45 mm x 120.5 mm (2.4 x 1.77 x 4.74)
USART-Ax-xFO, ETH-Bx-xFO (without protection cover)	61 mm x 45 mm x 132.5 mm (2.4 x 1.77 x 5.22)
ANAI-CA-4EL	61 mm x 45 mm x 119.5 mm (2.4 x 1.77 x 4.7)
ARC-CD-3FO	61 mm x 45 mm x 120.5 mm (2.4 x 1.77 x 4.74)

Minimum Bending Radii of the Connecting Cables Between the On-Site Operation Panel and the Base Module

Fiber optic cable	R = 50 mm Pay attention to the length of the cable protection sleeve, which you must also include in calculations.
D-Sub cable	R = 50 mm (minimum bending radius)

Degree of Protection to IEC 60529

For equipment in the surface-mounting housing	IP50
For equipment in the flush-mounting housing	Front IP51 Back side of the modular devices IP50 Back side of the non-modular devices IP40
For operator protection	IP2x for current terminal (installed removed) IP1x for voltage terminal (removed/without cover) IP2x for voltage terminal (removed/with cover) IP2x for voltage terminal (installed)
Degree of pollution, IEC 60255-27	2
Maximum altitude above sea level	2000 m (6561.68 ft)

[20] Width and depth rounded to whole numbers in mm
[21] Width and depth rounded to whole numbers in mm

UL Note

Type 1 if mounted into a door or front cover of an enclosure. When expanding the device with the 2nd device row, then they must be mounted completely inside an enclosure.

Tightening Torques for Terminal Screws

Type of Line	Current Terminal	Voltage Terminal with Spring-Loaded Terminals	Voltage Terminal with Screw Connection
Litz wire with ring-type lug	2.7 Nm	No ring-type lug	No ring-type lug
Stranded wires with boot-lace ferrules or pin-type lugs	2.7 Nm	1.0 Nm	0.6 Nm
Solid conductor, bare (2 mm²)	2.0 Nm	1.0 Nm	–

NOTE

Use copper cables only

Torques for Other Screw Types

Screw Type	Torque
M4 x 20	1.2 Nm
M4 x 8	1.2 Nm
M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 6	0.39 Nm
Countersunk screw, M2.5 x 8	0.39 Nm
Collar screw, M4 x 20	0.7 Nm

12.2 Protection Interface and Protection Topology

Setting Values

Mode	On Off	
PPS synchronization	Telegr. and PPS Telegr. or PPS PPS synchronization off	
Blocking of the unbalanced runtimes	Yes No	
Maximum signal runtime threshold	0.1 ms to 30.0 ms	Increments of 0.1 ms
Maximum runtime difference	0.000 ms to 3.000 ms	Increments of 0.001 ms
Failure indication after	0.05 s to 2.00 s	Increments of 0.01 s
Failure indication after	0.0 s to 6.0 s	Increments of 0.1 s
Max. error rate/h	0.000 % to 100.000 %	Increments of 0.001 %
Max. error rate/min	0.000 % to 100.000 %	Increments of 0.001 %
PPS failure indication after	0.5 s to 60.0 s	Increments of 0.1 s

Transmission Rate

Direct connection:	
Transmission rate	2048 kbit/s
Connection via communication networks:	
Supported network interfaces	G703.1 with 64 kBit/s G703-T1 with 1.455 MBit/s G703-E1 with 2.048 MBit/s X.21 with 64 kBit/s or 128 kBit/s or 512 kBit/s Pilot wires with 128 kBit/s
Transmission rate	64 kBit/s at G703.1 1.455 MBit/s at G703-T1 2.048 MBit/s at G703-E1 512 kBit/s or 128 kBit/s or 64 kBit/s at X.21 128 kBit/s for pilot wires

Transmission Times

Priority 1		
Response time, total approx.		
For 2 ends	Minimum	8 ms
	Typical	10 ms
For 3 ends	Minimum	10 ms
	Typical	14 ms
For 6 ends	Minimum	15 ms
	Typical	18 ms
Dropout times, total approx.		
For 2 ends	Typical	20 ms
For 3 ends	Typical	20 ms
For 6 ends	Typical	26 ms

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Priority 2		
Response time, total approx.		
For 2 ends	Minimum	9 ms
	Typical	16 ms
For 3 ends	Minimum	12 ms
	Typical	13 ms
For 6 ends	Minimum	17 ms
	Typical	23 ms
Dropout times, total approx.		
For 2 ends	Typical	24 ms
For 3 ends	Typical	25 ms
For 6 ends	Typical	32 ms

Priority 3[2]		
Response time, total approx.		
For 2 ends	Minimum	
	Typical	100 ms
For 3 ends	Minimum	
	Typical	150 ms
For 6 ends	Minimum	
	Typical	200 ms
Dropout times, total approx.		
For 2 ends	Typical	100 ms
For 3 ends	Typical	150 ms
For 6 ends	Typical	200 ms

[2] Times cannot be determined because the signals are transmitted in fragments.

12.3 Date and Time Synchronization

Date format	DD.MM.YYYY (Europe)
	MM/DD/YYYY (USA)
	YYYY-MM-DD (China)
Time source 1, time source 2	None
	IRIG-B 002(003)
	IRIG-B 006(007)
	IRIG-B 005(004) with extension according to IEEE C37.118-2005
	DCF77
	PI (protection interface)[3]
	SNTP
	IEC 60870-5-103
	DNP3
	IEEE 1588
Time zone 1, time zone 2	Local
	UTC
Failure indication after	0 s to 3600 s
Time zone and daylight saving time	Transfer of PC settings
	Manually setting the time zones
Time zone offset with respect to GMT	-720 min to 840 min
Switching over to daylight saving time	Active
	Inactive
Beginning of daylight saving time	Input: day and time
End of daylight saving time	Input: day and time
Offset daylight saving time	-120 to 120 [steps of 15]

[3] PI provided

12.4 Analog-Units Function Group

20-mA Unit Ether. 7XV5674-0KK00-1AA1

Max. number of connected 20-mA units	4
Max. number of channels per 20-mA unit	12

20-mA Unit Serial 7XV5674-0KK30-1AA1 (RS485) and 7XV5674-0KK40-1AA1 (fiberglass)

Max. number of connected 20 mA units	4
Max. number of channels per 20-mA unit	12

RTD Unit (Ziehl TR1200) 7XV5662-6AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 as per EN 60751

RTD Unit (Ziehl TR1200 IP) 7XV5662-8AD10

Max. number of connected RTD units	4
Max. number of sensors per RTD unit	12
Sensor type	Pt 100 as per EN 60751; connection of Ni 100 and Ni 120 sensors possible. The measured values must be converted in the evaluation unit.

Temperature Measured Values

Unit of measurement for temperature	°C or °F, can be adjusted
Pt 100	-199 °C to 800 °C (-326 °F to 1472 °F)
Resolution	1 °C or 1 °F
Tolerance	±0.5 % of the measured value ±1 K

12.5 Overcurrent Protection, Phases

12.5.1 Stage with Definite-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value[4]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[5] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

[4] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 I_{rated}
[5] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[6] (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [7]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [8]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) [9]
Time delays	1 % of the setting value or 10 ms

[6] In case that the filter response exactly matches the user-defined gain factors
[7] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.
[8] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.
[9] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.5.2 Stage with Inverse-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.00 to 15.00	Increments of 0.01
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Extension of the operate time during operation with transformer inrush current detection	Approx. 10 ms

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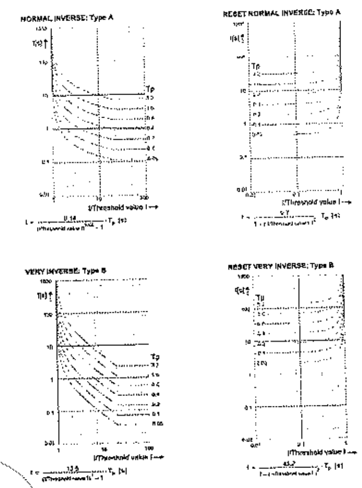


Figure 12-1 Operate Curves and Dropout-Time Characteristic Curves According to IEC

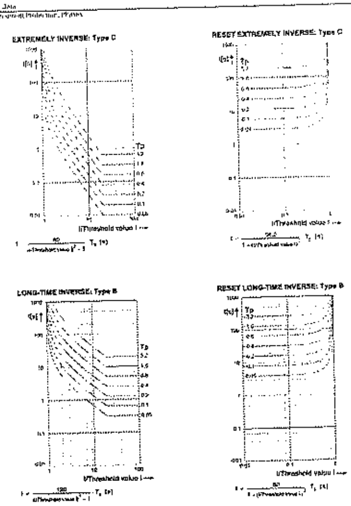


Figure 12-2 Operate Curves and Dropout-Time Characteristic Curves According to IEC

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

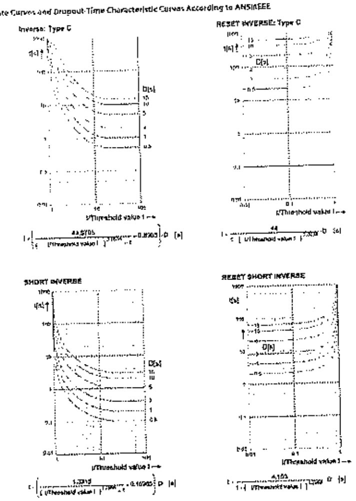


Figure 12-3 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

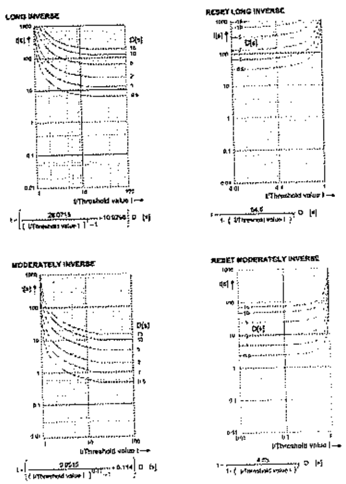


Figure 12-4 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

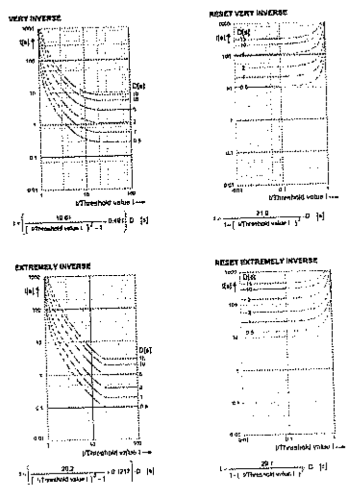
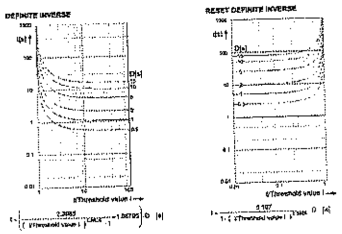


Figure 12-5 Tripping Characteristic Curves and Dropout Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead of the I threshold.

Figure 12-6 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < $0.9 f_{rated}$ $1.1 f_{rated}$ < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

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Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[40]) (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} = 10 %)[41]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)[42]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)[43]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.5.3 Stage with User-Defined Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	

[40] In case that the filter response exactly matches the user-defined gain factors
[41] In case that the user-defined gain factor is set below 1. The tolerance increases, if the gain factor is larger.
[42] In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.
[43] In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

Time multiplier	0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve	2 to 30	Increments of 1
X values of the operate curve	1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve	0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve	2 to 30	Increments of 1
X values of the dropout characteristic curve	0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve	0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} = 10 %)

Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation[44]) (33 % harmonics, in relation to the fundamental component)	
Up to 30 harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)[45]
Up to 50th harmonic, f_{rated} = 50 Hz	3% of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} = 10 %)[46]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} = 10 %)[46]
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[43] In case that the filter response exactly matches the user-defined gain factors
[44] In case that the user-defined gain factor is set below 1. The tolerance increases, if the gain factor is larger.
[45] In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.
[46] In case that the user-defined gain factor is set below 7. The tolerance increases, if the gain factor is larger.

12.6 Voltage-Dependent Overcurrent Protection, Phases

Setting Values for All Stage Types

Method of measurement		Fundamental component RMS value	–
Overcurrent threshold value	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
Time delay		0.10 s to 60.00 s	Increments of 0.01 s

Setting Values for Inverse Time-Overcurrent Stages

Method of measurement	Fundamental component RMS value	–
Dropout ratio of undervoltage[47]	1.01 to 1.20	Increments of 0.01
Undervoltage threshold value[47]	0.300 V to 175.000 V	Increments of 0.001 V
Dropout	Disk emulation Instantaneous	–
Time multiplier	0.05 to 15.00	Increments of 0.01

Setting Values for Definite Time-Overcurrent Stages

Seal-in voltage	0.300 V to 175.000 V	Increments of 0.001 V
Phase-to-phase voltage	0.300 V to 175.000 V	Increments of 0.001 V
Negative-sequence voltage V2	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Duration of V-seal-in time	0.10 s to 60.00 s	Increments of 0.01 s

Dropout for Inverse Time-Overcurrent Stages

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout	
Current	95 % of 1.1 · threshold value
Voltage[47]	105 % of threshold value
Minimum absolute dropout differential	
Protection class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer[47]	150 mV sec.

Reset of the Integration Timer for Inverse Time-Overcurrent Stages

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

[47] The value is for the inverse time-overcurrent voltage-released stage.

Dropout for Definite Time-Overcurrent Stages

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with inrush-current detection	Approx. 10 ms

The operate curves and dropout-time characteristic curves according to IEC can be found in the chapter Technical Data under Inverse-Time Overcurrent Protection.

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

The operate curves and dropout-time characteristic curves according to IEC can be found in the chapter Technical Data under Inverse-Time Overcurrent Protection.

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Currents, method of measurement = RMS value (33 % part of harmonic in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltage	0.5 % of the setting value or 0.05 V
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

ВЯРНО С ОРИГИНАЛА

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12.7 Overcurrent Protection, Ground

12.7.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value[17]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[18] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

[17] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$
[18] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 12.1.4 Relay Outputs

Tolerances

3I0 measured via I4[19], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[19], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pick up in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	≤ 5 %

12.7.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value[20]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.00 to 15.00	Increments of 0.01
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

[19] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2
[20] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2
[21] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

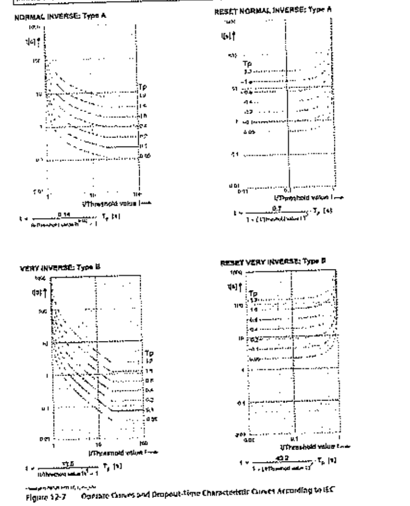

Figure 12-7 Operate Curves and Dropout-Time Characteristic Curves According to IEC

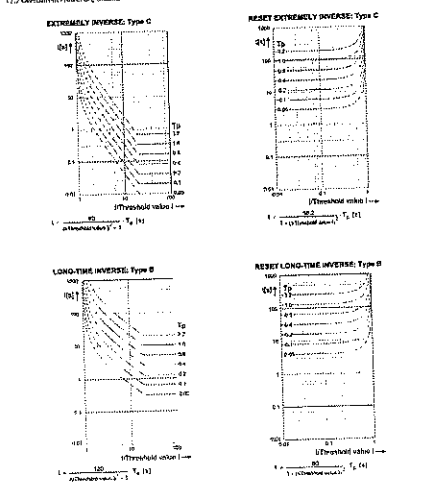

Figure 12-8 Operate Curves and Dropout-Time Characteristic Curves According to IEC

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

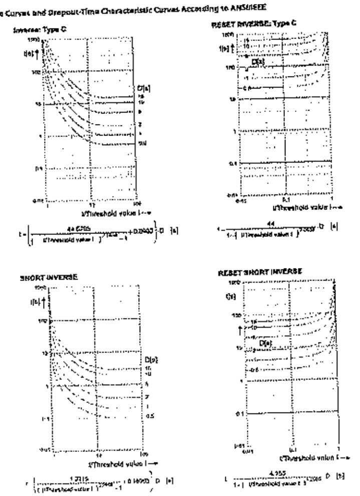

Figure 12-9 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

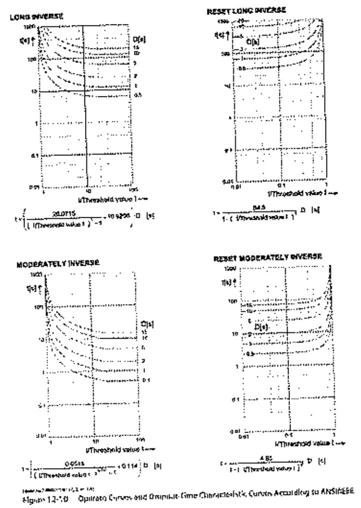

Figure 12-10 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

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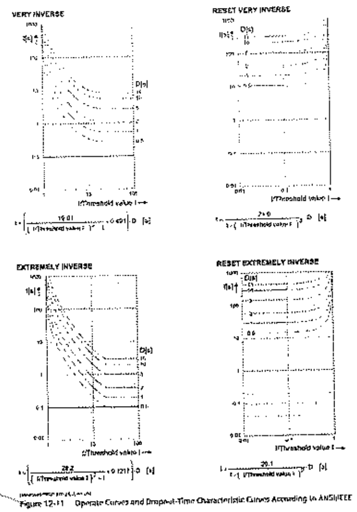
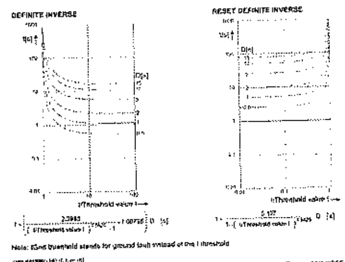


Figure 12-11 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



Note: 3I0 threshold stands for ground fault instead of the I threshold

Figure 12-12 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

3I0 measured via I4[4], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[5], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

[4] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2
[5] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

Dropout time for 2 ≤ I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.7.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances

$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

3I0 measured via I4[6], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
3I0 measured via I4[7], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[6] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2
[7] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

12.8 Directional Overcurrent Protection, Phases

12.8.1 Stage with Definite-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value[8]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT[9] at 50 Hz Approx. 32 ms + OOT at 60 Hz

[8] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$
[9] OOT (Output Operating Time) additional delay of the output medium used, [illegible]

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delay	1 % of the setting value or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.8.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Backward	–
Method of measurement		Fundamental component RMS value	
Threshold value[10]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	

[10] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$

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Time multiplier	0.00 to 15.00	Increments of 0.01
Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve, Figure 12-1
Very inverse: type B	
Extremely inverse: type C	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve, Figure 12-2
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve, Figure 12-3
Short inverse	
Long inverse	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve, Figure 12-4
Moderately inverse	
Very inverse	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve, Figure 12-5
Extremely inverse	
Definite inverse	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve, Figure 12-6

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.8.3 Stage with User-Defined Characteristic Curve

Setting Values

Rotation angle of the reference voltage	-180° to +180°	Increments of 1°
Directional mode	Forward Reverse	-
Method of measurement	Fundamental component RMS value	-

[1] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Threshold value [2]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate characteristic curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disc emulation	Approx. < 0.90 · threshold value

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT [3] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[2] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 I_{rated}
[3] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9 Directional Overcurrent Protection, Ground

12.9.1 Stage with Definite-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances

10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.2 Stage with Inverse-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Type of characteristic curve		Characteristic curves according to IEC and ANSI	
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.00 to 15.00	Increments of 0.01

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Maximum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	Refer to the respective figure of the technical data for the non-dir OC ground function 12.7.2 Stage with Inverse-Time Characteristic Curve
Very inverse: type B	
Extremely inverse: type C	
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	Refer to the respective figure of the technical data for the non-dir OC ground function 12.7.2 Stage with Inverse-Time Characteristic Curve
Short inverse	
Long inverse	
Moderately inverse	
Very inverse	
Extremely inverse	
Definite inverse	

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.3 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Characteristic curve: see Figure 12-13			
Threshold value multiplier		1.00 to 4.00	Increments of 0.01
Time multiplier		0.000 s to 60.000 s	Increments of 0.001 s
Minimum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s
Maximum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s

Additional time delay	0.000 s to 60.000 s	Increments of 0.001 s

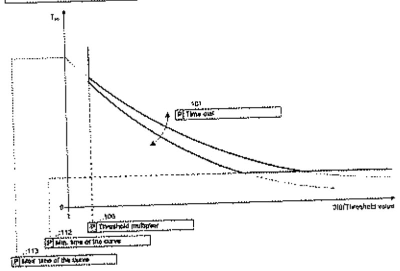

Figure 12-13 Operate Curve of Logarithmic Inverse-Time Characteristic

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances

10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Inverse-time operate time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.4 Stage with Knee-Point Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Characteristic curve: see Figure 12-14		
Minimum time of the characteristic curve	0.00 s to 30.00 s	Increments of 0.01 s
Knee-point time of the curve	0.00 s to 100.00 s	Increments of 0.01 s
Maximum time of the characteristic curve	0.00 s to 200.00 s	Increments of 0.01 s
Knee-point value	0.030 A to 35.000 A	Increments of 0.001 A
Current at minimum time of the curve	0.030 A to 35.000 A	Increments of 0.001 A
Time multiplier	0.05 to 1.50	Increments of 0.01

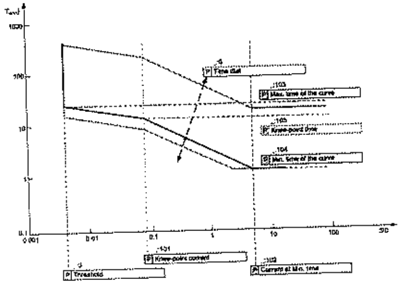

Figure 12-14 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (in the Example of Threshold = 0.004 A)

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Inverse-time operate time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.9.5 Stage with User-Defined Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

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Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01
X values of the operate curve		1.00 p. u. to 66.67 p. u.	Increments of 0.01 p. u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p. u. to 0.95 p. u.	Increments of 0.01 p. u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.10 Inrush-Current Detection

Setting Values

Operat. range limit Imax	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Component of 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of the cross-block function		0.03 s to 200.00 s	Increments of 0.01 s

Times

Pickup times	Approx. 29 ms

Dropout Ratios

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	0.95

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Current measurement I_{max}	1 % of the setting value or 5 mA
Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	1 % of the setting value for settings of $I_{2nd\ harm}/I_{1st\ harm}$
Time delays	1 % of the setting value or 10 ms

12.11 Arc Protection

Setting Values

Threshold I>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold 3I0>>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
External trip initiation		yes no	
Operating mode		Light only Current and light	
Sensor		Point sensor Line sensor Custom	
Threshold Light		-28.00 dB to 0.00 dB	Increments of 0.01
Channel		Possible settings, application-dependent	

Dropout

The larger dropout differential (= | pickup threshold - dropout threshold |) of the following 2 criteria is used:

Dropout differential derived from the Dropout ratio parameter If this parameter is not available, a dropout ratio of 95 % applies to the overcurrent protection and a dropout ratio of 105 % applies to the undercurrent protection.	
Minimum absolute dropout differential	
Protection class current transformers	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument transformers	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Shortest operate time Operating mode = light only	Approx. 2.6 ms + OOT[5]
Shortest operate time Operating mode = Current and light	Approx. 4.0 ms + OOT at 50 Hz Approx. 3.8 ms + OOT at 60 Hz

[5] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with a fast relay, see Chapter 12.1.4 Relay Outputs

12.12 Instantaneous High-Current Tripping

Setting Values

Threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 50 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.50 to 0.90	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time for current > 2 · threshold value	Approx. 8 ms + OOT[6]

Tolerances

Response tolerance, current	5 % of setting value or 10 mA at I_{rated} = 1 A 5 % of setting value or 50 mA at I_{rated} = 5 A
Time delays	1 % of the setting value or 10 ms

[6] OOT (Output Operating Time) Additional delay of the output medium used, see Chap. 12.1.4 Relay Outputs

12.13 Instantaneous Tripping at Switch onto Fault

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Tolerances

Times	< 1 % of the setting value or 10 ms

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12.14 Overcurrent Protection, 1-Phase

12.14.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value[a]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.95	-
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 15 ms + OOT[b] at 50 Hz Approx. 14 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 17 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

[a] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 I_{rated}.
[b] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 12.1.4 Relay Outputs

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.14.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value[a]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout

[a] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 I_{rated}.

Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

The tripping characteristic curves and dropout characteristic curves according to IEC can be found in the Technical Data chapter under Inverse-Time Overcurrent Protection.

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

The tripping characteristic curves and dropout characteristic curves according to ANSI/IEEE can be found in the Technical Data chapter under Inverse-Time Overcurrent Protection.

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

12.14.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement	Fundamental component RMS value	-

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with less sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 < I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

12.15 Overcurrent Protection, 1-Phase (Fast Stage)

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 8 ms + OOT[a]
Dropout time	Approx. 25 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Pickup tolerance, current	5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

[a] OOT (Output Operating Time) additional time delay of the output medium used, for example, 5 ms with fast relay

12.16 Non-Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0>	For current transformer type protection and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type protection and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and $I_{N,rated}$ = 1 A	For $I_{ph,rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and $I_{N,rated}$ = 5 A	For $I_{ph,rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pickups until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 100.00 s	Increments of 0.01 s
Reset time			1.00 s to 600.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[1] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with less sensitivity

[1] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Tolerances

Currents	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A)
Times	1 % of the setting value or + 10 ms

12.17 Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0>	For current transformer type protection and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type protection and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and $I_{N,rated}$ = 1 A	For $I_{ph,rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and $I_{N,rated}$ = 5 A	For $I_{ph,rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pickups until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 100.00 s	Increments of 0.01 s
Reset time			1.00 s to 600.00 s	Increments of 0.01 s
Number of pulses for operate			2 to 100	Increments of 1

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Pickup time	Approx. 30 ms + OOT[1] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with less sensitivity

[1] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Tolerances

Currents	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A)
Times	1 % of the setting value or + 10 ms

12.18 Sensitive Ground-Fault Detection

12.18.1 General

Setting Values

Decay time V0			0.06 s to 0.20 s	Increments of 0.01 s
Dropout delay			0.00 s to 60.00 s	Increments of 0.01 s
Core balance current transformer current 1 Core balance current transformer current 2	Protection-class current transformers	For $I_{ph,rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and $I_{N,rated}$ = 1 A	For $I_{ph,rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and $I_{N,rated}$ = 5 A	For $I_{ph,rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Core balance current transformer angle correction F1 Core balance current transformer angle correction F2			0.0° to 5.0°	Increments of 0.1°

Times

Pickup times	Approx. 25 ms + OOT[2] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout times	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances [3]
f < 10 Hz f > 80 Hz	Active with less sensitivity [4]

Tolerances

Currents	3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %)
	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %)
Voltages	1 % of the setting value or 0.05 V
Times	1 % of the setting value or ±10 ms

[2] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays
[3] Transient ground-fault stage is inactive
[4] Transient ground-fault stage is inactive

Direction-calculation angle error[5]	≤ 1° at 3I0 > 5 mA, V0 = 0.6 V ≤ 2° at 3I0 ≤ 5 mA, V0 = 0.6 V

12.18.2 Directional 3I0 Stage with Cos φ or Sin φ Measurement

Setting Values

Direction method of measurement			cos φ sin φ	-
Threshold value 3I0> Minimum directional 3I0> for direction determination	Protection-class current transformers	For $I_{ph,rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and $I_{N,rated}$ = 1 A	For $I_{ph,rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and $I_{N,rated}$ = 5 A	For $I_{ph,rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of the direction range α2 constraint of the direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[6] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[5] Not applicable to 12.18.4 Directional 3I0 Stage with φ(V0, 3I0) Measurement
[6] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.x Relay Outputs

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Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

12.18.3 Directional Transient Ground-Fault Stage

Setting Values

Threshold value 3I0>	Protection class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Maximum operational V0			0.300 V to 340.000 V	Increments of 0.001 V
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 115 ms + OOT[7] at 50 Hz Approx. 112 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 15 ms + OOT at 60 Hz

[7] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

12.18.4 Directional 3I0 Stage with φ(V0,3I0) Measurement

Setting Values

Threshold value 3I0>	Protection-class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Min. V0> for direction determination			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
Rotation angle of the reference voltage			-180° to 180°	Increments of 1°
Forward range +/-			0° to 180°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 23 ms + OOT[8] at 50 Hz Approx. 21 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 23 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz

Tolerances

Direction-calculation angle error	≤ 1° at 3I0 ≥ 10 mA, V0 ≥ 0.6 V ≤ 2° at 2 mA ≤ 3I0 < 10 mA, V0 ≥ 0.6 V ≤ 3° at 3I0 ≤ 2 mA, V0 ≥ 0.6 V

[8] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

12.18.5 Directional Y0 Stage with G0 or B0 Measurement (Admittance)

Setting Values

Direction method of measurement			B0 G0	-
Release threshold value 3I0>	Protection-class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Threshold value Y0>			0.10 mS to 100.00 mS	Increments of 0.01 mS
Time delay of direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of direction range α2 constraint of direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[9] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

[9] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1.6 A) or 0.25 mS (I_{rated} = 8 A), (f_{rated} ± 10 %)

12.18.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Setting Values

Threshold value[10]	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[11] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[10] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.
[11] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

12.18.7 Non-Directional 3I0 Stage

Setting Values

Method of Measurement			Fundamental component RMS value	
Threshold value 3I0>	Protection-class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For transformer type I-sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For transformer type I-sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Pickup delay			0.00 s to 60.00 s	Increments of 0.01 s
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[12] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

12.18.8 Non-Directional Y0 Stage

Setting Values

V0> threshold value	0.300 V to 200.000 V	Increments of 0.001 V
Threshold Y0>	0.10 mS to 100.00 mS	Increments of 0.01 mS

[12] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[13] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1.6 A) or 0.25 mS (I_{rated} = 8 A), (f_{rated} ± 10 %)

[13] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

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12.19 Undercurrent Protection

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value I<	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time	Approx. 25 ms + OOT[54] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Currents, method of measurement = fundamental component	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % portion harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

[54] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter Relay Outputs

Up to 30th harmonic, f_{rated} = 50 Hz	3 % of setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

12.20 Negative-Sequence Protection

12.20.1 Stage with Definite-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated,obj}$ Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout ratio		0.40 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

- Dropout differential derived from the parameter Dropout ratio
- Dropout differential of 3 % of the subject rated current

Times

Pickup time	Approx. 40 ms + OOT[55] at 50 Hz Approx. 35 ms + OOT at 60 Hz
Dropout time	Approx. 35 ms + OOT

Current Operating Range

Current range	At least one phase current ≥ setting value $I_{ph,max}$ All phase currents ≤ setting value $I_{ph,max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

[55] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

Tolerances

Pickup value	
$I_2/I_{rated,obj}$	Approx. 2 % of the setting value or 0.8 % of the absolute value
I_2/I_1	Approx. 2 % of the setting value or 4 % of the absolute value (I_1 > 50 mA (I_{rated} = 1 A) or 250 mA (I_{rated} = 5 A))
Time delays	1 % of the setting value or 10 ms

12.20.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated,obj}$ Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout		Disk emulation Instantaneous	
Time multiplier		0.05 to 15.00	Increments of 0.01
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

- Dropout differential derived from the parameter Dropout ratio
- Dropout differential of 3 % of the object rated current

Times

Pickup time	Approx. 40 ms + OOT[56] at 50 Hz Approx. 35 ms + OOT at 60 Hz
Dropout time	Approx. 35 ms + OOT

Dropout Ratio

Disk emulation	Approx. 0.90 · threshold value
Instantaneous	Approx. 1.05 · threshold value Approx. 0.95 · pickup value

[56] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

Operate and Dropout Characteristic Curves

You can select from the following operate and dropout characteristic curves:

Table 12-3 Standard Characteristic Curves to IEC

Normal inverse: type A	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve , Figure 12-1
Very inverse: type B	
Extremely inverse: type C	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve , Figure 12-2
Long-time inverse: type B	

Table 12-4 Standard Characteristic Curves to ANSI

Inverse: type C	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve , Figure 12-3
Short inverse	
Long inverse	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve , Figure 12-4
Moderately inverse	
Very inverse	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve , Figure 12-5
Extremely inverse	
Definite inverse	See chapter 12.5.2 Stage with Inverse-Time Characteristic Curve , Figure 12-6

Extension of the Operating Time

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

Current Operating Range

Current range	At least one phase current ≥ setting value $I_{ph,max}$ All phase currents ≤ setting value $I_{ph,max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Reference value = rated current	
Pickup value	Approx. 2 % of the setting value or 0.8 % of the absolute value
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the setting value or + 2 % of the current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the setting value or + 2 % of the current tolerance or 30 ms
Reference value = pos. seq. current	
Pickup value	Approx. 2 % of the setting value or 4 % of the absolute value (I1 > 50 mA (I_{rated} = 1 A) or 250 mA (I_{rated} = 5 A))

Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

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12.21 Directional Negative-Sequence Protection with Definite-Time Delay

Setting Values

Directional mode	Forward, Backward, Non-directional	
Stabilization with phase currents	0 % to 30 %	Increments of 1 %
Threshold value (pickup value) at I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
Threshold value (pickup value) at I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
Extension time of the blocking after 1-pole pause	0.00 s to 60.00 s	Increments of 0.01 s

Setting Values for Direction Determination

Minimum negative-sequence system voltage V2		0.150 V to 20.000 V	Increments of 0.001 V
Minimum negative-sequence system current I2	For I_{rated} = 1 A	0.030 A to 10.000 A	Increments of 0.001 A
	For I_{rated} = 5 A	0.15 A to 50.00 A	Increments of 0.01 A
Upper limit angle forward, β		0° to 360°	Increments of 1°
Lower limit angle forward, α		0° to 360°	Increments of 1°

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

- Dropout differential derived from the parameter Dropout ratio
- Dropout differential of 3 % of the object rated current

Times

Operate time with time delay = 0 ms	Approx. 40 ms + OOT[1] at 50 Hz
	Approx. 40 ms + OOT at 60 Hz
Dropout time	Approx. 39 ms + OOT

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated}	Slightly expanded tolerances
1.1 f_{rated} < f ≤ 80 Hz	
f < 10 Hz	Inactive
f > 80 Hz	

Tolerances

Threshold values:	
Negative-sequence voltage V2	1 % of the setting value or 0.5 V
Negative-sequence current I2	2 % of the setting value or 10 mA at I_{rated} = 1 A
	1 % of the setting value or 5 mA at I_{rated} = 5 A
Times:	
Independent time delays	1 % of the setting value or 10 ms

[1] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

Limit angle in discriminating the direction	5°

12.22 Thermal Overload Protection, 3-Phase

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values/Increments for the Protection Stage

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
Emerg. start T overtravel		0 s to 15 000 s	Increments of 10 s
K-factor acc. to IEC 60255-8		0.10 to 4.00	Increments of 0.01
Thermal time constant		10 s to 60 000 s	Increments of 1 s
Cooling time constant		10 s to 60 000 s	Increments of 1 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Imin cooling	1 A @ 50 and 100 Irated	0.000 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Temperature rise at Irated		40 K to 200 K	Increments of 1 K
Default temperature		-55°C to 55°C	Increments of 1°C
Minimal temperature		-55°C to 40°C	Increments of 1°C

Dropout Ratios

Tripping threshold (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold	About 0.99 of the setting value
Current warning threshold	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

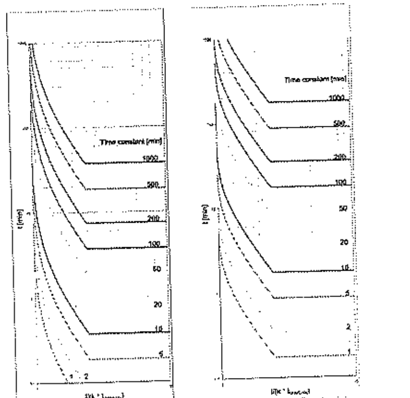
Tolerances

No filter applied (33 % harmonics, in relation to the fundamental component)		
With reference to k · I_{rated}	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-8
With the filter for compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)		
With reference to k · I_{rated}	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 50 Hz	3 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 3 % class acc. to IEC 60255-8
	Up to 50th harmonic, f_{rated} = 60 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8
With the filter for gain of harmonics including compensation of the amplitude attenuation[2] (33 % harmonics, in relation to the fundamental component)		
With reference to k · I_{rated}	Up to 30th harmonic	2 % or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), 2 % class acc. to IEC 60255-8[3]
	Up to 50th harmonic, f_{rated} = 50 Hz	4 % or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), 4 % class acc. to IEC 60255-8[3]
	Up to 50th harmonic, f_{rated} = 60 Hz	5 % or 25 mA (I_{rated} = 1 A) or 125 mA (I_{rated} = 5 A), 5 % class acc. to IEC 60255-8[3]
With reference to the operate time	Up to 30th harmonic	3 % or 1 s for $I/(k \cdot I_{rated})$ > 1.25, 3 % class acc. to IEC 60255-8

Operate Curve

Operate curve	$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1}$	
Where	t	Operate time
	τ_{th}	Time constant
	I	Current 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

[2] In case that the filter response exactly matches the user-defined gain factors.
[3] In case that the user-defined gain factor is set below 1, the tolerance is increased if the gain factor is larger.
[4] In case that the user-defined gain factor is set below 1, the tolerance is increased if the gain factor is larger.



With 60 % preload and with $I_{max,therm}$ = 2.5 · k · I_{rated}

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \text{ [min]}$$

Without preload and with $I_{max,therm}$ = 2.5 · k · I_{rated}

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \text{ [min]}$$

Figure 12-15 Operate Curve of Overload Protection

12.23 Thermal Overload Protection, User-Defined Characteristic Curve

Setting Values

Threshold current warning	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold thermal warn.		50 % to 100 %	Increments of 1 %
Dropout threshold operate		50 % to 99 %	Increments of 1 %
Emerg. start T overtravel		0 s to 15 000 s	Increments of 10 s
Imax thermal	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Imin cooling	1 A @ 50 and 100 Irated	0.000 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.00 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.000 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.000 A to 8.000 A	Increments of 0.001 A
Curve based on preload		1 % to 100 %	Increments of 1 %
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.10 p.u. to 20.00 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		1.00 s to 70 000.00 s	Increments of 0.01 s

Dropout Ratios

Tripping threshold (fixed at 100 %)	Dropout if value drops below operate indication dropout threshold
Thermal warning threshold	About 0.99 of the setting value
Current warning threshold	About 0.95 of the setting value

Frequency Range of the Input Signals

The function captures input signals up to the 50th harmonic.

Tolerances

With reference to k · I_{rated}	For I_{rated} = 1 A	2 % or 10 mA, class 2 % acc. to IEC 60255-8
	For I_{rated} = 5 A	2 % or 50 mA, class 2 % acc. to IEC 60255-8
With reference to operate time		3 % or 1 s, class 3 % acc. to IEC 60255-8 for $I/(k \cdot I_{rated})$ > 1.25

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12.24 Unbalanced-Load Protection

Setting Values

Maximum continuously perm. I2	3.0 % to 30.0 % I2 / $I_{rated,machine}$	Increments of 0.1 %
Unbalanced load factor K	1.0 s to 100.0 s	Increments of 0.1 s
Warning delay	0.0 s to 60.0 s	Increments of 0.1 s
Cooling time thermal replica	0 s to 50 000 s	Increments of 1 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

- Dropout differential derived from a dropout ratio of 95 %
- Dropout differential of 1 % of the object rated current

Operate Characteristics

Characteristic of the thermal replica	$t_{Perm} = \frac{K}{(I_2/I_{rated,machine})^2}$	
Where:	t_{Perm}	Permissible application time of the negative-sequence current
	K	Unbalanced load factor K
	$I_2/I_{rated,machine}$	Unbalanced load (negative-sequence current/rated current of the machine)

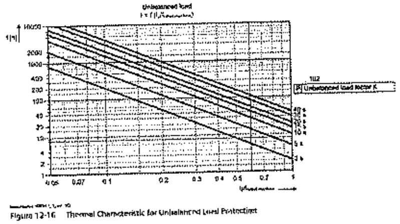

Figure 12-16 Thermal Characteristic for Unbalanced Load Protection

Times

Pickup time of the warning stage	Approx. 60 ms + OOT[1] at 50 Hz Approx. 50 ms + OOT at 60 Hz

[1] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays

Dropout time	Approx. 50 ms or better

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Negative sequence current I_2	Approx. 3 % of setting value or 0.030 A at I_{rated} = 1 A Approx. 3 % of setting value or 0.150 A at I_{rated} = 5 A
Warning delay	1 % of the setting value or 10 ms
Time for $2 \le I_2/I_{rated} \le 20$	5 % of reference (calculated) value or 100 ms + (1 % current tolerance or 10 mA) at I_{rated} = 1 A 5 % of reference (calculated) value or 100 ms ± (1 % current tolerance or 50 mA) at I_{rated} = 5 A

Influencing Variables for the Thresholds

Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

12.25 Current-Unbalance Protection for Capacitors, 3-Phase

Setting Values for the Function

Automatic compensation		Yes No	
Time between switch off and switch on		0.00 s to 60.00 s	Increments of 0.01 s
Normalization with Ic		Yes No	
Threshold of defective C-element	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Setting Values (Overcurrent-Protection Stage I>)

Measured value		compensated non-compensated	
I_{unbal}	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
I_{unbal}	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s

Setting Values (Counter Stage)

Type of counting groups	segregated sum	
Max. no. of def. elem. phs A	1 to 1000	Increments of 1
Max. no. of def. elem. phs B	1 to 1000	Increments of 1
Max. no. of def. elem. phs C	1 to 1000	Increments of 1
Operate delay	0.00 s to 10000.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[2] at 50 Hz Approx. 29 ms + OOT at 60 Hz

[2] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents I_c, I_{unbal} Protection-class current transformers	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents I_{unbal} Sensitive current transformer	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms

12.26 Current-Unbalance Protection for Capacitors, 1-Phase

Setting Values for the Function

Automatic compensation		Yes No	
Time between switch off and switch on		0.00 s to 60.00 s	Increments of 0.01 s
Normalization with Ic		Yes No	
Threshold of defective C-element	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Setting Values (Overcurrent-Protection Stage I>)

Current threshold I_{unbal}	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.150 A to 175.000 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.005 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Measured value			compensated non compensated

Setting Values (Counter Stage)

Type of counting groups		segregated sum
Type of counting phases		segregated sum
Max. no. of def. elem. phs A	1 to 1000	Increments of 1
Max. no. of def. elem. phs B	1 to 1000	Increments of 1
Max. no. of def. elem. phs C	1 to 1000	Increments of 1
Max. no. of def. elem.	1 to 1000	Increments of 1
Operate delay	0.00 s to 10000.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[3] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents I_c, I_{unbal} Protection-class current transformers	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10%)
Currents I_{unbal} Sensitive current transformer	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A), (f_{rated} ± 10%)
Time delays	1 % of the setting value or 10 ms

[3] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

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12.27 Voltage-Differential Protection for Capacitor Banks

Setting Values (General Functionality)

Voltage-matching factor k	0.5000 to 2000.0000	Increments of 0.0001

Setting Values (Protection Stage V_{diff}>)

Threshold	0.005 p.u. to 1.000 p.u.[25]	Increments of 0.001 p.u.
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

Dropout ratio for set. threshold ≥ 3 V	95 %
Dropout differential for set. threshold 0.3 V to 3 V	150 mV
Dropout ratio for sec. threshold 0.2 V to 0.3 V	50 %

Times

Operate time with time delay = 0 ms	Approx. 30 ms + OOT (Output Operating Time) at 50 Hz Approx. 27 ms + OOT (Output Operating Time) at 60 Hz
Dropout time	Approx. 20 ms + OOT (Output Operating Time) at 50 Hz Approx. 18 ms + OOT (Output Operating Time) at 60 Hz

Tolerances

Threshold ≥ 0.2 V	1 % of the setting value or 0.05 V (compensated)
Time delays	1 % of the setting value or 10 ms

Operating Range of the Secondary Differential Voltage

Operating Range of the secondary differential voltage	≥ 0.1 V (compensated)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

[25] Minimum secondary setting threshold = 0.2 V

12.28 Differential Protection for Capacitor Banks

Setting Values

Operate Curve			
Threshold value	$I/I_{rated,obj}$	0.05 to 2.00	Increments of 0.01
Gradient 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Irest	$I/I_{rated,obj}$	0.00 to 5.00	Increments of 0.01
Gradient 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Irest	$I/I_{rated,obj}$	1.00 to 20.00	Increments of 0.01
Startup Recognition			
Startup threshold value	$I/I_{rated,obj}$	0.1 to 2.0	Increments of 0.1
Characteristic-curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum start-up time		0.1 s to 180.0 s	Increments of 0.1 s
DC-Component Recognition			
Characteristic-curve increase factor DC		1.0 to 5.0	Increments of 0.1
Inrush-current detection			
Content 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of crossblk. 2. har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
Recognition of External Faults			
Additional stabilization threshold value	$I/I_{rated,obj}$	1.00 to 20.00	Increments of 0.01
Additional stabilization duration		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Operate curve		See Figure 12-17	

Idiff Fast

Threshold value	$I/I_{rated,obj}$	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout Ratio

Idiff stage	Approx. 0.7
Idiff fast stage	Approx. 0.8

Response Tolerance

For preset characteristic-curve parameters; for 2 sides with one measuring point each	
Idiff stage and characteristic curve	2 % of the setting value
Idiff fast stage	2 % of the setting value

Time Delays

Idiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Idiff fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

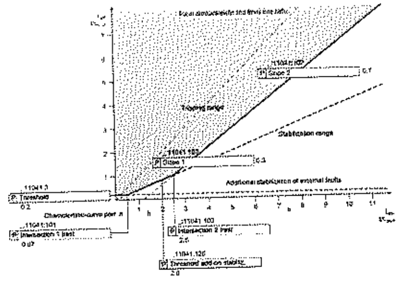

Figure 12-17 Operate Curve of the Differential Protection

Operating Times

Operate times for infeed on one side		
Idiff stage, min	50 Hz	23 ms + OOT[26]
	60 Hz	20 ms + OOT[1]
Idiff fast stage, min	50 Hz	8 ms + OOT[1]
	60 Hz	8 ms + OOT[1]
Dropout time, approx.	50 Hz	29 ms
	60 Hz	26 ms

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 90 Hz	Slightly expanded tolerances
f < 10 Hz f > 90 Hz	Active

[26] Refer to protection functions, for example, Overcurrent protection

12.29 Overvoltage Protection with 3-Phase Voltage

Setting Values for Stage Type Definite Time-Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value[16]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 300.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Setting Values for Stage Type Inverse Time-Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value	0.300 V to 340.000 V	Increments of 0.001 V
Pickup factor	1.00 to 1.20	Increments of 0.01
Characteristic constant k	0.00 to 300.00	Increments of 0.01
Characteristic constant α	0.010 to 5.000	Increments of 0.001
Characteristic constant c	0.000 to 5.000	Increments of 0.001
Time multiplier	0.05 to 15.00	Increments of 0.01
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s
Reset time	0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve for Stage Type Inverse Time-Overvoltage Protection

$$T_{op} = T_{inv} + T_{Add}$$

Where

T_{op} Operate delay
T_{inv} Inverse-time delay
T_{Add} Additional time delay (parameter Additional time delay)

$$T_{inv} = T_p \left(\frac{k}{\left(\frac{V}{V_{thresh}}\right)^{\alpha} - 1} + c \right) [s]$$

Where

T_{inv} Inverse-time delay
T_p Time multiplier (parameter Time dial)
V Measured voltage

[16] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.

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)

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[17] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances for Stage Type Definite Time-Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

Tolerances for Stage Type Inverse Time-Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Operate time for 1.2 ≤ V/V threshold value ≤ 20	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

[17] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

12.30 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Setting Values

Method of Measurement	RMS value Fundamental component Fundamental component over 2 cycle filters	
Block. on measuring-voltage outage	Yes No	
Determ. ph. aff. by grd. flt.	Yes No	
Threshold value[18]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 320.00 s	Increments of 0.01 s
Dropout Ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[19] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout Time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances

[18] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.
[19] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

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f < 10 Hz f > 80 Hz	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

12.31 Overvoltage Protection with Positive-Sequence Voltage

Setting Values

Pickup value	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[19] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[19] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 12.1.4 Relay Outputs

12.32 Overvoltage Protection with Negative-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle

Setting Values

Pickup value of V2	0.300 V to 200.000 V	Increments of 0.001 V
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT[20] (depends on the measuring window length) at 50 Hz 48 ms to 185 ms + OOT (depends on the measuring window length) at 60 Hz
Dropout time	20 ms to 78 ms + OOT (depends on the measuring window length)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[20] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.33 Overvoltage Protection with Any Voltage

Setting Values

Measured value[21]	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[22]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[23] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V

[21] If the function Overvoltage protection with any voltage is used in a 1-phase function group, the measured value parameter is not visible.
[22] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.
[23] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 12.1.4 Relay Outputs

Time delays	1 % of the setting value or 10 ms

12.34 Peak Overvoltage Protection for Capacitors

Setting Values

Threshold value Inverse-time stage Definite-time stage User-defined characteristic curve	0.80 to 3.00 p.u. 0.80 to 10.00 p.u. 0.80 to 3.00 p.u.	Increments of 0.01 Increments of 0.01 Increments of 0.01
Tripping delay	0.01 s to 3600.00 s	Increments of 0.01 s
Dropout delay	0.00 s to 3600.00 s	Increments of 1.00 s
Down integration time	1 min to 1500 min	Increments of 1 min
Time multiplier	0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve	30	Increments of 1
X values of the operate curve	1.00 p.u. to 4.00 p.u.	Increments of 0.01 p.u.
Y values of the operate curve	0.00 s to 9999.99 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve	30	Increments of 1
X values of the dropout characteristic curve	0.01 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve	0.00 s to 9999.99 s	Increments of 0.01 s

Inverse-Time Characteristic Curve (IEC/IEEE)

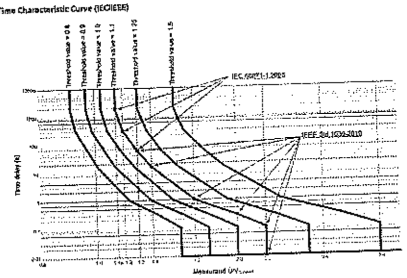

Figure 12-18 Inverse-Time Characteristic Curve

The points on the characteristic curve defined in the standards result from a threshold setting of 1.1. These single points are connected via semi-logarithmic line segments.

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Table 12-5 Peak Overvoltage Inverse-Time Characteristic (for Threshold Setting 1.1)

Measurand V/V_{rated}	Time Delay	Curve Point According to
< 1.15	∞ (no pickup)	Siemens definition
1.15	1800.00 s	IEC 60871-1:2005
1.2	300.00 s	IEC 60871-1:2005
1.3	60.00 s	IEC 60871-1:2005, IEEE Std 1036-2010
1.4	15.00 s	IEEE Std 1036-2010
1.7	1.00 s	IEEE Std 1036-2010
2	0.25 s	IEEE Std 1036-2010
2.2	0.1 s	IEEE Std 1036-2010
> 2.2	0.01 s	IEEE Std 1036-2010

Times

Pickup time	Approx. 35 ms + OOT at 50 Hz[1] Approx. 25 ms + OOT at 60 Hz[1]
Dropout Time	Depending on settings
[1] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays	

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Peak overvoltage (33 % harmonics, with reference to fundamental component)	
Up to 30th harmonic Up to 50th harmonic, f_{rated} = 50 Hz Up to 50th harmonic, f_{rated} = 60 Hz	1 % of the setting value or 0.005 p.u. (f_{rated} ± 10%) 3 % of the setting value or 0.02 p.u. (f_{rated} ± 10%) 4 % of the setting value or 0.02 p.u. (f_{rated} ± 10%)
Time delays	
Measured value of inverse-time stage	5 % of the setting value +1 % of the measured value or 30 ms
Measured value of definite-time stage	1 % of the setting value or 10 ms
Down integration time	5 % of the setting value or 30 ms

12.35 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V

Setting Values for Stage Types

Pickup value of V2/V1	0.50 % to 100.00 %	Increments of 0.01 %
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value – dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 210 ms + OOT[??] (depends on the measuring-window length) at 50 Hz 48 ms to 190 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout times	22 ms to 55 ms + OOT (depends on the measuring-window length) at 50 Hz 18 ms to 45 ms + OOT (depends on the measuring-window length) at 60 Hz

Frequency Operating Range

$0.9\ f/f_{rated}$ to $1.1\ f/f_{rated}$	According to specified tolerances
10 Hz to $0.9\ f/f_{rated}$ $1.1\ f/f_{rated}$ to 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[??] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.36 Undervoltage Protection with 3-Phase Voltage

Setting Values for Stage Type Definite Time-Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Pickup value[??]		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Setting Values for Stage Type Inverse Time-Undervoltage Protection

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold		0.300 V to 175.000 V	Increments of 0.001 V
Pickup factor		0.80 to 1.00	Increments of 0.01
Characteristic constant k		0.00 to 300.00	Increments of 0.01
Characteristic constant α		0.010 to 5.000	Increments of 0.001
Characteristic constant c		0.000 to 5.000	Increments of 0.001
Time multiplier		0.05 to 15.00	Increments of 0.01
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s
Reset time		0.00 s to 60.00 s	Increments of 0.01 s

Operate Curve

$T_{op} = T_{inv} + T_{add}$

Where:

T_{op} Operate delay

T_{inv} Inverse-time delay

T_{add} Additional time delay (parameter Additional time delay)

[??] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.

$$T_{inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{thresh}} \right)^{\alpha}} + c \right) [s]$$

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)

Dropout

The greater dropout differential (= | pickup value – dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 25 ms + OOT[??] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances for Stage Type Definite Time-Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

[??] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 12.1.4 Relay Outputs

Tolerances for Stage Type Inverse Time-Undervoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %), valid for instrument transformers
Operate time for $0 < V/V_{thresh} < 0.9$	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

12.37 Undervoltage Protection with Positive-Sequence Voltage

Setting Values

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Pickup value		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value – dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time	Approx. 25 ms + OOT[??] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V

[??] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 12.1.4 Relay Outputs

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Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} = 10 %), valid for protection-class current transformers
	1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} = 10 %), valid for instrument transformers
Time delays	1 % of the setting value or 10 ms

12.38 Undervoltage Protection with Any Voltage

Setting Values

Measured value	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated phase-to-phase voltage V_{AB} Calculated phase-to-phase voltage V_{BC} Calculated phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[16]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[17] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms - OOT

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive, maintained; Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[16] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.
[17] OOT (Output Operating Time) additional delay of the output medium used, see chapter 12.1.4 Relay Outputs

12.39 Overfrequency Protection

Setting Values

Pickup values f>	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f>	Angle difference method	
	50 Hz	Approx. 70 ms + OOT[11]
	60 Hz	Approx. 60 ms + OOT
	Filtering method	
	50 Hz	Approx. 75 ms + OOT
	60 Hz	Approx. 75 ms + OOT
Dropout times f>	60 ms to 80 ms	

Dropout

The larger dropout differential (= | pickup value - dropout threshold |) of the following 2 criteria is used:

Dropout differential derived from the Dropout ratio parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f>	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f>)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

[11] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see chapter 12.1.4 Relay Outputs

12.40 Underfrequency Protection

Setting Values

Pickup values f<	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f<	Angle difference method	
	50 Hz	Approx. 70 ms + OOT[12]
	60 Hz	Approx. 60 ms + OOT
	Filtering method	
	50 Hz	Approx. 75 ms + OOT
	60 Hz	Approx. 75 ms + OOT
Dropout times f<	60 ms to 80 ms	

Dropout

The larger dropout differential (= | pickup value - dropout threshold |) of the following two criteria is used:

Dropout differential derived from the Dropout ratio parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f<	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f<)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

[12] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relay, see chapter 12.1.4 Relay Outputs

12.41 Rate of Frequency Change Protection

Setting Values for the Function

Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V
Measuring window	2 periods to 5 periods	Increments of 1 period

Setting Values for Stage Types

Threshold	0.1 Hz/s to 20.0 Hz/s	Increments of 0.1 Hz/s
Dropout differential	0.02 Hz/s to 0.99 Hz/s	Increments of 0.01 Hz/s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 165 ms to 225 ms (depends on measuring window length)
Dropout time	Approx. 165 ms to 225 ms (depends on measuring window length)

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Threshold, measuring window > 3 periods	Approx. 3 % or 0.06 Hz/s
Threshold, measuring window < 3 periods	Approx. 5 % or 0.06 Hz/s
Minimum voltage	1 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

12.42 3-Phase Power Protection (P,Q)

Setting Values

Measured value	Positive sequence power Power of phase A Power of phase B Power of phase C	
Threshold value	-200.0 % to +200.0 %	Increments of 0.1
Tilt-power characteristic	-89.0° to +89.0°	Increments of 0.1°
Dropout delay time	0.00 s to 60.00 s	Increments of 0.01 s
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	Upper stage: 0.90 to 0.99 Lower stage: 1.01 to 1.10	Increments of 0.01 Increments of 0.01

Times

Pickup times	Approx. 55 ms + OOT[13] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout times	Approx. 55 ms + OOT at 50 Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Power	0.5 % S_{rated} ± 3 % of setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms

Variables That Influence Pickup Values

Auxiliary DC voltage in the range $0.8 \leq V_{Aux}/V_{AuxRated} \leq 1.15$	≤ 1 %
Frequency in the range $0.95 \leq f/f_{rated} \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % of 3rd harmonics - Up to 10 % of 5th harmonics	≤ 1 % ≤ 1 %

[13] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 12.1.4 Relay Outputs

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12.43 Reverse-Power Protection

Setting Values

Reverse power $P_{reverse}$ (p.u.)	-0.30 % to -30.00 %	Increments of 0.01 %
Angle correction	-10.00 ° to 10.00 °	Increments of 0.01 °
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V
Tripping delay	0.00 s to 60.00 s	0.00 s to 60.00 s
Tripping delay with quick stop	0.00 s to 60.00 s	0.00 s to 60.00 s
Dropout delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.40 to 0.99	Increments of 0.01

Times

Pickup times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz
Dropout times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Reverse power	0.15 % S_{rated} or 5 % of the setting value when $Q < 0.5\ S_{rated}$
Time delays	1 % or 10 ms

12.44 Overexcitation Protection

Setting Values

Threshold value (characteristic curve dependent on pickup)		$\frac{U/U_{rated}}{f/f_{rated}}$	1.00 to 1.20	Increments of 0.01
Threshold value (characteristic curve independent on pickup)		$\frac{U/U_{rated}}{f/f_{rated}}$	1.00 to 1.40	Increments of 0.01
Time delay (warning delay and tripping delay)			0.00 s to 60.00 s	Increments of 0.01 s
Characteristic value pairs			2 to 30	
	Value ranges	V/f	1.00 p.u. to 10.00 p.u.	Increments of 0.01 p.u.
		t	0 s to 100 000 s	Increments of 1 s
Cooling time therm. replica			0 s to 100 000 s	Increments of 1 s

Functional Measured Values

Measured Value	Description
(_:2311:322) V/F	Value calculated from voltage and frequency.
(_:[illegible]) Therm.charact.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, tripping occurs.

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Operating Times

Operate times/dropout times		
Operate time at frequency	50 Hz	60 Hz
Minimum	33 ms + OOT	30 ms + OOT[1]
Dropout time	10 ms + OOT	10 ms + OOT

Dropout Ratios

Warning, tripping (independent stage)	Approx. 0.98

Operate Curve

Thermal replica	For default setting refer to the following characteristic curve Figure 12-19

Tolerances

V/f pickup	2 % of the setting value
Time delays	1 % of the setting value or 10 ms (min. 1.5 periods)
Thermal replica	5 % based on V/f ± 600 ms

[1] Refer to protection functions, for example overcurrent protection

Voltage measurement accuracy	0.5 % of the setting value or 0.5 V in the range fn ± 10 %
Frequency measurement accuracy	1.0 % of the setting value or 1.0 Hz in the frequency range 10 Hz to 80 Hz

Influencing Quantities

Auxiliary direct voltage in the 0.8 range	≤ 1 %
Time delays	< 0.5 %/10 K
Thermal replica	≤ 1 %
Harmonics	
Up to 10 % of 3rd harmonic Up to 10 % of 5th harmonic	≤ 1 % ≤ 1 %

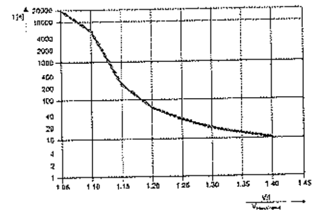

Figure 12-19 Operate Curve from the Thermal Replica of the Overexcitation Protection (Default Setting)

12.45 Undervoltage-Controlled Reactive-Power Protection

Setting Values

Threshold value	Power Q	1.00 % to 200.00 %	Increments of 0.01 %
	Voltage of protection stage	3.000 to 175.000	Increments of 0.001 V
	Voltage of reclosure stage	3.000 V to 340.000 V	Increments of 0.001 V
Current I_1 release threshold	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Release time delay of reclosure stage		0.00 s to 3600.00 s	Increments of 0.01 s

Dropout Ratio

Protection stage	
Reactive-power flow Q	Approx. 0.95
Voltage	Approx. 1.05
Release current	Approx. 0.95
Reclosure stage	
Voltage	Approx. 0.95
Release current	Approx. 0.95

Times

Pickup time	Approx. 55 ms + OOT[1] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout time	Approx. 55 ms + OOT at 50 Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Current I_1	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Voltage	0.5 % of the setting value or 0.05 V
Power Q	0.5 % S_{rated} ± 3 % of the setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms
Reclosure time delay	1 % of the setting value or 10 ms

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances

[1] OOT (Output Operating Time) and time delay of the output medium used, for example 5 ms with fast relays

f < 10 Hz f > 80 Hz	Active

12.46 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	3-pole tripping internal or external[1]

Setting Values

Phase-current threshold values	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Sensitive threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Supervision time of release signal		0.06 s to 1.00 s	Increments of 0.01 s
Time delays		0.05 s to 60.00 s	Increments of 0.001 s
Supervision time of binary inputs		0.05 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Circuit-Breaker Supervision

Position supervision via circuit-breaker auxiliary contacts	
For 3-pole CB tripping	1 input each for make contact and break contact

NOTE

The circuit-breaker failure protection can also work without the circuit-breaker auxiliary contacts stated. Auxiliary contacts are required for circuit-breaker failure protection in cases where the current flow is absent or too low for tripping (for example with a transformer or a Buchholz protection).

[1] Via binary inputs

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Times

Pickup time, in the case of an internal start Pickup time, in the case of an external start	< 1 ms < 5 ms
Typical dropout time	< 15 ms
Dropout time via circuit-breaker auxiliary-contact criterion	< 5 ms

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10 Hz \le f < 0.9 f_{rated}$ $1.1 f_{rated} < f \le 80 Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Threshold values, dropout thresholds	2 % of the setting value or 1 % of the rated current
Times	1 % of the setting value or 10 ms

12.47 Circuit-Breaker Restrike Protection

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Monitoring duration		1.00 s to 600.00 s	Increments of 0.01 s
Position recognition delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Trip delay time		0.05 s to 60.00 s	Increments of 0.01 s
Retrip delay time		0.00 s to 60.00 s	Increments of 0.01 s
Minimum operate (trip) time		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10 Hz \le f < 0.9 f_{rated}$ $1.1 f_{rated} < f \le 80 Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Threshold	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

12.48 Restricted Ground-Fault Protection

Setting Values

Threshold value[11]	0.05 A to 2.00 A	Increments of 0.01 A
Gradient	0.00 to 0.95	Increments of 0.01
Operate curve	See figure	
Pickup tolerance (for preset characteristic curve parameters; for 2 sides with 1 measuring point each)	2 %	
Tripping delay	0.00 s to 60.00 s or ∞ (no tripping)	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion
(_:311) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF
(_:312) I angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF
(_:301) I diff.	Differential current
(_:302) I restr.	Restraint current

Dropout Ratio

Threshold value	0.7

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

7UT82/7UT85/7UT86/7UT87		
Frequency	50 Hz	60 Hz
	Operate time	Operate time

[11] The specified setting limit can be dynamically further limited, depending on the transformer adaptation factor. (for this refer to Chapter 6.41.4 Application and Setting Notes).

At 1.5 · setting value threshold value At 2.5 · setting value threshold value	33 ms + OOT 27 ms + OOT	32 ms + OOT 26 ms + OOT
Dropout time approx.	80 ms	67 ms

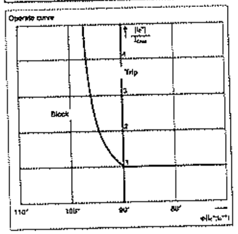

Figure 12-20 Restricted Ground-Fault Protection Operate Curve depending on the Phase Angle between I_0'' and I_0''' at $|I_0''| = |I_0'''|$ (180° = External fault)

12.49 External Trip Initiation

Setting Values

Tripping delay	0.00 s to 60.00 s	Increments of 0.01 s

Times

Operate time with time delay = 0 ms At initiation via binary input signal	Approx. 10 ms + OOT[118]

Tolerance

Sequence tolerance for delay times	1 % of the setting value or 10 ms

[118] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays, see chapter 12.1.4 Relay Outputs

12.50 Automatic Reclosing

Function specifications	Cyclic automatic reclosing function Automatic reclosing function with adaptive dead time (ADT) Operation with External Automatic Reclosing Function	
Number of reclosings	Max. 8, per individual settings	
Type (depending on the order variation)	1-pole, 3-pole, or 1-/3-pole	
Operating mode of the automatic reclosing function	With trip command, without action time With trip command, with action time With pickup, without action time With pickup, with action time	
Reclaim time after reclosing	0.50 s to 300.00 s	Increments of 0.01 s
Blocking time after dynamic blocking	0.5 s	-
Blocking time after manual closure	0.00 s to 300.00 s	Increments of 0.01 s
Start supervision time	0.01 s to 300.00 s	Increments of 0.01 s
Circuit-breaker supervision time	0.01 s to 300.00 s	Increments of 0.01 s
Evolving-fault detection	With trip command with Pickup	
Reaction to evolving faults	Blocks automatic reclosing function Start, evolving fault, dead time	
Action times (separated for all cycles)	0.00 s to 300.00 s or ∞ (ineffective)	Increments of 0.01 s
Dead times after trip command (separated for all types and all cycles)	0.00 s to 1 800.00 s or ∞ (ineffective)	Increments of 0.01 s
Dead time after evolving-fault detection (separated for all cycles)	0.00 s to 1 800.00 s	Increments of 0.01 s
Synchrocheck after 3-pole dead time	None Internal External	
Transmission delay, inter close command	0.00 s to 300.00 s or ∞ (ineffective)	Increments of 0.01 s
Dead-line check/reduced dead time	Without Reduced dead time (VWE) Dead-line checking	
Voltage supervision warning time	0.10 s to 30.00 s	Increments of 0.01 s
Limiting value for fault-free line	0.3 V to 340.0 V	Increments of 0.1 V
Limiting value for zero potential	0.3 V to 340.0 V	Increments of 0.1 V

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12.51 Fault Locator

Setting Values

Reactance per unit length of the line per kilometer or per mile Line length for the correct output of the fault distance as a percentage of the line length The residual compensation factors in the setting format Kr and Kx or K0 and angle (K0)	
Consideration of the load current for 1-pole ground faults	Correction of the X value, for connection and deactivation

Fault Distance

Output of the fault distance (line length)	In Ω primary and secondary In km, miles or in percent. [14]

Tolerances

Measuring tolerances during sinusoidal measurands and error duration > 25 ms at 60 Hz or > 30 ms at 50 Hz	1.5 % from fault location at V_K/V_{rated} ≤ 0.01 and one of the following scenarios: • Metal fault • Non-metallic fault for one-side infeed without load

[14] The output of the fault distance in km, miles and percent presupposes a homogeneous line.

12.52 Temperature Supervision

Setting Values

Pickup value	-50 °C to 250 °C -58 °F to 482 °F	Increments of 1 °C Increments of 1 °F
Time delay	0 s to 60 s or ∞	Increments of 1 s

Dropout Conditions

Dropout differential	3 °C or 6 °F

Tolerances

Tripping delay	±1 % of the setting value or ±10 ms
Measured temperature value	±0.5 % of the setting value or ±1 °C or ±2 °F

12.53 Current-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT [17] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Currents	3 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[17] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.54 Voltage-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT [17] at 50 Hz Approx. 8 ms + OOT at 60 Hz

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Voltages	2 % of the setting value or 0.100 V for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[17] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

12.55 Synchronization Function

Operating Modes

Synchrocheck
Switching synchronous systems
Switching asynchronous systems
De-energized switching
Direct closing command

Setting Values

Supervision/Delay times:		
Max. Duration of synchronization process	0.00 s to 3 600.00 s or ∞ (ineffective)	Increments of 0.01 s
Supervision time de-energized switching	0.00 s to 60.00 s	Increments of 0.01 s
Closure delay	0.00 s to 60.00 s	Increments of 0.01 s
Voltage threshold values:		
Upper voltage limit V_{max}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
Lower voltage limit V_{min}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
V<, for off-circuit conditions V>, for voltage present	0.300 V to 170.000 V (phase-to-phase) 0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V Increments of 0.001 V
Differential values, changeover thresholds asynchronous/synchronous:		
Voltage differences V2 > V1; V2 < V1	0.000 V to 170.000 V	Increments of 0.001 V
Frequency difference f2 > f1; f2 < f1	0.000 Hz to 2.000 Hz (synchronous) 0.000 Hz to 4.000 Hz (asynchronous)	Increments of 0.001 Hz
Angular difference α2 > α1; α2 < α1	0° to 90°	Increments of 1°
Δf threshold ASYN <-> SYN	0.010 Hz to 0.200 Hz	Increments of 0.001 Hz
Adjustments of the sides:		
Angle adjustment	0.0° to 360.0°	Increments of 0.1°
Voltage adjustment	0.500 to 2.000	Increments of 0.001
Circuit breaker		
Closing time of the circuit breaker	0.01 s to 0.60 s	Increments of 0.01 s

Dropout Ratio

Min./max. operating limit	1 % of the setting value
Voltage differential	10 % of the setting value or 0.5 V
De-energized/energized	5 % of the setting value
Frequency difference	3 mHz
Angular difference	0.1°

Measured Values of the Synchronization Function

Reference voltage V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Voltage to be synchronized V2 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Frequency of the voltage V1 f1 • Range • Tolerance at rated frequency	f1 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Frequency of the voltage V1 f2 • Range • Tolerance at rated frequency	f2 in Hz 25 Hz ≤ f ≤ 70 Hz 1 mHz
Voltage difference V2-V1 • Range • Tolerance at rated frequency	In kV primary, in V secondary or in % V_{rated} Display always as phase-to-phase voltage in relation to side 1 10 % to 120 % of V_{rated} ≤ 1% of the measured value or 0.5% V_{rated}
Frequency difference f2-f1 • Range • Tolerance at rated frequency	In mHz f_{rated} ± 10 % 1 mHz
Angular difference λ2-λ1 • Range • Tolerance at rated frequency	In ° -180° to +180° 0.5°

Times

Measuring time, after switching on the variables	Approx. 80 ms

Operating Range

Voltage	20 V to 340 V
Frequency	f_{rated} -4 Hz ≤ f_{rated} ≤ f_{rated} +4 Hz

Tolerances

Tolerances of the voltage settings	2 % of the pickup value or 1 V
Voltage difference V2>V1; V2<V1	1 V
Frequency difference f2>f1; f2<f1	10 mHz
Angular difference α2>α1; α2<α1	1°
Tolerance of all time settings	10 ms
Max. phase displacement angle	5° for Δf ≤ 1 Hz 10° for Δf > 1 Hz

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12.56 Voltage Controller

Setting Values

General information		
I reference for % values	0.20 A to 100 000.00 A	Increments of 0.01 A
V reference for % values	0.20 kV to 1 200,00 kV	Increments of 0.01 kV
Volt. cont. 2W		
Target voltage 1	40,00 kV to 1 360,00 kV	Increments of 0.01 kV
Target voltage 2		
Target voltage 3		
Target voltage 4		
Volt. cont. 3W and GC		
Target voltage 1 w1	40,00 kV to 1 360,00 kV	Increments of 0,01 kV
Target voltage 2 w1		
Target voltage 3 w1		
Target voltage 4 w1		
Target voltage 1 w2		
Target voltage 2 w2		
Target voltage 3 w2		
Target voltage 4 w2		
Volt. cont. 2W, 3W, and GC		
Bandwidth	0,2 % to 10,0 %	Increments of 0.1 %
T1 delay	5 s to 600 s	Increments of 1 s
T1 Inverse Min	5 s to 100 s	Increments of 1 s
T2 delay	0 s to 100 s	Increments of 1 s
Fast step down limit	0.0 % to 50,0 %	Increments of 0.1 %
Fast step down T delay	0.0 s to 10,0 s	Increments of 0.1 s
Fast step up limit	-50,0 % to 0.0 %	Increments of -0.1 %
Fast step up T delay	0,0 s to 10,0 s	Increments of 0.1 s
Function monitoring	1 min to 120 min	Increments of 1 min
Line compensation LDC-Z		
Target voltage rising	0.0 % to 20,0 %	Increments of 0.1 %
Max load current	0,0 % to 500,0 %	Increments of 0,1 %
Line compensation LDC-X and R		
R line	0,0 Ω to 30,0 Ω	Increments of 0.1 Ω
X line	-30.0 Ω to 30.0 Ω	Increments of 0.1 Ω
Limiting values		
Vmin threshold	40,00 kV to 1 360,00 kV	Increments of 0,01 kV
Vmin time delay	0 s to 20 s	Increments of 1 s
Vmax threshold	40,00 kV to 1 360,00 kV	Increments of 0.01 kV
Vmax time delay	0 s to 20 s	Increments of 1 s
Blockings		
V< Threshold	40,00 kV to 1 360,00 kV	Increments of 0.01 kV
V< Time delay	0 s to 20 s	Increments of 1 s
I> Threshold	10 % to 500 %	Increments of 1 %
I> Time delay	0 s to 20 s	Increments of 1 s
I< Threshold	3 % to 100 %	Increments of 1 %

I< Time delay	0 s to 20 s	Increments of 1 s

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 over 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 over measured (referenced to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding
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

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

Measured Value	Description	Primary	Secondary	% Referenced to
V tar. w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

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

Dropout Ratio

Threshold of the voltage limit	About 0,99 of the setting value
Threshold of the current limit	About 0,99 of the setting value

12.57 Current-Balance Supervision

Setting Values

Release threshold	1 A @ 100 Irated	0,030 A to 35,000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0,15 A to 175,00 A	Increments of 0,01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0,001 A to 1,600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0,005 A to 8,000 A	Increments of 0.001 A
Threshold value min/max		0,10 to 0,95	Increments of 0.01
Tripping delay		0,00 s to 100,00 s	Increments of 0,01 s

Dropout Ratio

Overcurrent dropout ratio	About 0.97
Undercurrent dropout ratio	About 1,05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.58 Voltage-Balance Supervision

Setting Values

Release threshold value	0,300 V to 170,000 V	Increments of 0.001 V
Threshold value min/max	0.58 to 0.95	Increments of 0.01
Tripping delay	0.00 s to 100,00 s	Increments of 0.01 s

Dropout Ratio

Overvoltage dropout ratio	Approx. 0.97
Undervoltage dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.59 Current-Sum Supervision

Setting Values

Slope of the characteristic curve		0,00 to 0,95	Increments of 0,01
Threshold	1 A @ 50 and 100 Irated	0,030 A to 10,000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0,15 A to 50,00 A	Increments of 0,01 A
	1 A @ 1.6 Irated	0,001 A to 1,600 A	Increments of 0,001 A
	5 A @ 1.6 Irated	0,005 A to 8 000 A	Increments of 0.001 A
Tripping delay		0,00 s to 100,00 s	Increments of 0,01 s

Dropout Ratio

Dropout ratio	About 0,97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

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12.60 Voltage-Sum Supervision

Setting Values

Threshold value	0,300 V to 170,000 V	Increments of 0,001 V
Tripping delay	0,00 s to 100,00 s	Increments of 0,01 s

Dropout Ratio

Dropout ratio	Approx. 0,97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.61 Current Phase-Rotation Supervision

Setting Values

Tripping delay	0,00 s to 100,00 s	Increments of 0,01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.62 Voltage Phase-Rotation Reversal

Setting Values

Tripping delay	0,00 s to 100,00 s	Increments of 0,01 s
Phase-rotation direction	A B C A C B	

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

12.63 Trip-Circuit Supervision

Setting Values

Number of monitored circuits per circuit-breaker function group	1 to 3	
Operating mode per circuit	With 1 binary input With 2 binary inputs	
Pickup and dropout time	About 1 s to 2 s	
Adjustable indication delay with 1 binary input	1,00 s to 600,00 s	Increments of 0,01 s
Adjustable indication delay with 2 binary inputs	1,00 s to 600,00 s	Increments of 0,01 s

12.64 Analog Channel Supervision via Fast Current Sum

Times

Pickup times	Approx. 2 ms (faster than the fastest protection function)
Dropout time	Approx. 100 ms

Blockings

Blocked functions	All functions that process the measured values from this current measuring point (for example, differential protection).

12.65 Measuring-Voltage Failure Detection

Setting Values

3ph.fail. - VA,VB,VC <		0,300 V to 340,000 V	Increments of 0,001 V
3ph.fail. - phs.curr.release	1 A @ 50 and 100 Irated	0,030 A to 35,000 A	Increments of 0,001 A
	5 A @ 50 and 100 Irated	0,15 A to 175,00 A	Increments of 0,01 A
	1 A @ 1.6 Irated	0,001 A to 1,600 A	Increments of 0,001 A
	5 A @ 1.6 Irated	0,005 A to 8,000 A	Increments of 0,001 A
3ph.fail. - phs.curr. jump	1 A @ 50 and 100 Irated	0,030 A to 35,000 A	Increments of 0,001 A
	5 A @ 50 and 100 Irated	0,15 A to 175,00 A	Increments of 0,01 A
	1 A @ 1.6 Irated	0,001 A to 1,600 A	Increments of 0,001 A
	5 A @ 1.6 Irated	0,005 A to 8,000 A	Increments of 0,001 A
Asym.fail. - time delay		0,00 s to 30,00 s	Increments of 0,01 s
SO 3ph.fail. - time delay		0,00 s to 30,00 s	Increments of 0,01 s

Dropout

The larger dropout differential (= | pickup value - dropout threshold |) of the following 2 criteria is used:

Dropout differential derived from the Dropout ratio parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 10 ms + OOT[72] at 50 Hz Approx. 10 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Times

Use in function group Line	
Pickup time	Approx. 10 ms + OOT[73] at 50 Hz Approx. 9 ms + OOT at 60 Hz
Use in other function group types	
Pickup time	Approx. 20 ms + OOT[74] at 50 Hz Approx. 18 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

[72] OOT (Output Operating Time) Additional delay of the output medium used, see chapter 12.1.4 Relay Outputs
[73] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter 12.1.4 Relay Outputs
[74] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter 12.1.4 Relay Outputs

f < 10 Hz f > 80 Hz	Active

Tolerances

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltages	0.5 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

12.66 Voltage-Transformer Circuit Breaker

Setting Values

Response time	0.000 s to 0.030 s	Increments of 0.001 s

12.67 Operational Measured Values and Statistical Values

The following applies to the tolerances of currents and voltages:

- The values apply both to the RMS values and the absolute value and phase angle of the fundamental components.
- The values were determined for pure sinusoidal signals – without harmonics.

Voltages

V_A, V_B, V_C Voltage range	V secondary < 200 V secondary
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC (0.8 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
V_{AB}, V_{BC}, V_{CA} Voltage range	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC (0.8 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Instrument Transformers

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 100 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 to 25 A 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 50 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 to 25 A 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.6 % of the measured value in the above mentioned measuring range

Currents, Sensitive Ground-Current Transformer

$3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Phase Angle

ΦV	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz

Tolerance ΦV	0.2 ° at rated voltage
ΦI	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦI	0.2 ° at rated current

Power Values

Active power P	W secondary
Measuring range Voltage range Current range Frequency range	|cos φ| ≥ 0.01 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range
Reactive power Q	var secondary
Measuring range Voltage range Current range Frequency range	|sin φ| ≥ 0.984 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	1.0 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	1.5 % of the measured value in the above mentioned measuring range
Apparent power S	VA
Measuring range Voltage range Current range Frequency range	(0.01 to 2) · S_{rated} (0.8 to 1.2) · V_{rated} (0.01 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range

Frequency

Frequency f	Hz

Range	f_{rated} - 0.20 Hz < f_{rated} + 0.20 Hz
Tolerance	± 5 mHz in the V_{rated} range
Range	f_{rated} - 3.00 Hz < f_{rated} + 3.00 Hz
Tolerance	± 10 mHz in the V_{rated} range
Frequency range (expanded)	25 Hz to 80 Hz: operational measured values 10 Hz to 80 Hz: functional measured values, system frequency
Tolerance	20 mHz in the range f_{rated} ± 10 % for rated values

Statistical Values of the Device

Device operating hours	h
Range	0 to 9 999 999 h
Tolerance	1 h

Statistical Values of the Circuit Breaker

Op.cnt. (operation counter)	
Range	0 to 999 999 999
Tolerance	None
∑I Off (sum of the primary currents switched off)	A, kA, MA, GA, TA, PA primary
Range	0 to 9.2 e+15
Operating hours	h
Range	0 to 9 999 999 h
Tolerance	1 h
Circuit breaker open hours	h
Range	0 to 9 999 999 h
Tolerance	1 h

Statistical Values of the Disconnector

Op.cnt. (operation counter)	
Range	0 to 999 999 999
Tolerance	None

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12.68 Energy Values

Setting Values

Active energy W_p	kWh, MWh, GWh
Reactive energy W_q	kvarh, Mvarh, Gvarh
Range	≤ 2 % for I > 0.1 I_{rated} V > 0.1 V_{rated} |cos φ| ≥ 0.707
Tolerance at rated frequency	1 %

12.69 Phasor Measurement Unit

Accuracy

As per IEEE Std C37.118.1a-2014

Synchrophasor Standard

IEEE Std C37.118.1 2011

12.70 Circuit-Breaker Wear Monitoring

Setting Values

Threshold value	ΣI*-method stage	0 to 10 000 000	Increments of 1
	2P-method stage	0 to 10 000 000	Increments of 1
	I²t-method stage	0.00 I²r*s to 21 400 000.00 I²r*s	Increments of 0.01
CB opening time		0.001 s to 0.500 s	Increments of 0.001 s
CB break time		0.001 s to 0.600 s	Increments of 0.001 s
CB make time		0.001 s to 0.600 s	Increments of 0.001 s
Exponent for the ΣI*-method		1.0 to 3.0	Increments of 0.1
Switching cycles at I_{rated}		100 to 1 000 000	Increments of 1
Rated short circuit breaking current I_{sc}		10 to 100 000	Increments of 1
Switching cycles at I_{sc}		1 to 1000	Increments of 1
Level of warning 1		1 % to 100 %	Increments of 1 %
Level of warning 2		1 % to 100 %	Increments of 1 %
Operating current threshold	1 A at 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Delay correction time		-0.050 s to 0.050 s	Increments of 0.001 s

Tolerances

Tolerance of the measured value make time	± 2 ms

12.71 CFC

Typical response times and maximum number of ticks of the CFC task levels:

Task Level	Time (in ms)	Ticks for Non-Modular Devices with CP100	Ticks for Modular Devices with CP200	Ticks for Modular Devices with CP300
Fast Event-Triggered	<1	500	500	1000
Event-Triggered	<10	12 367	12757	14702
Interlocking	<10	117 564 in total	121 537 in total	141 398 in total
Measurement	250			

The times describe the response time of a typical CFC chart at the respective task level. The maximum number of ticks applies to a typical load for the device based on the application template Directional time-overcurrent protection, grounded electrical power system. The maximum number can be lower in case of extensive protection applications.

The task level Measurement runs in cycles every 500 ms. All other task levels are event-triggered.

In order to estimate the tick consumption of a CFC chart, you can use the following formula:

$$T_{chart} = 5 \cdot n_{inp} + 5 \cdot n_{outp} + T_{TLev} + \sum_i T_{BI} + \sum_j T_{Block}$$

where:

n_{inp} Number of indications routed as input in the CFC chart

n_{outp} Number of indications routed as output in the CFC chart

T_{TLev} 101 Ticks in Fast Event Triggered Level
104 Ticks in Event-Triggered Level
54 Ticks in Measurement Level
74 Ticks in Interlocking Level

T_{BI} Number of internal connections between 2 CFC blocks in one chart

T_{Block} Used ticks per CFC block (see Technical Data)

Table 12-6 Ticks of the Individual CFC Blocks

Element	Ticks
ABS_D	2.3
ABS_R	1.5
ACOS_R	6.9
ADD_D4	3.4
ADD_R4	3.3
ADD_XMV	6.4
ALARM	1.8
AND_SPS	1.1
AND10	2.6
APC_DEF	1.2
APC_EXE	1.0
APC_INFO	3.9
ASIN_R	1.3
ATAN_R	1.2
BLINK	1.3
BOOL_CNT	2.0
BOOL_INT	1.5

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Element	Ticks
BSC_DEF	1.3
BSC_EXE	1.1
BSC_INFO	2.7
BUILD_ACD	2.0
BUILD_ACT	2.2
BUILD_BSC	1.2
BUILD_CMV	2.3
BUILD_DEL	2.1
BUILD_DPS	1.4
BUILD_ENS	1.3
BUILD_INS	0.5
BUILD_Q	0.8
BUILD_SPS	0.6
BUILD_WYE	8.2
BUILD_XMV	7.9
BUILDC_Q	3.0
CHART_STATE	5.0
CMP_DPS	1.5
CON_ACD	0.7
CON_ACT	0.5
CONNECT	0.4
COS_R	2.5
CTD	1.8
CTU	1.6
CTUD	2.3
DINT_REAL	3.0
DINT_UINT	3.0
DIV_D	2.9
DIV_R	1.6
DIV_XMV	2.2
DPC_DEF	0.4
DPC_EXE	0.4
DPC_INFO	1.1
DPC_OUT	1.3
DPS_SPS	1.0
DRAGI_R	1.7
EQ_D	1.0
EQ_R	1.9
EXP_R	1.5
EXPT_R	2.7
F_TRGM	0.3
F_TRIG	0.3
FF_D	0.9
FF_D_MEM	1.4
FF_RS	0.7
FF_RS_MEM	1.3
FF_SR	0.8

Element	Ticks
FF_SR_MEM	1.1
GE_D	0.9
GE_R	1.1
GT_D	0.9
GT_R	1.2
HOLD_D	1.1
HOLD_R	1.0
INC_INFO	0.9
LE_D	1.1
LE_R	1.1
LIMI_R	1.5
LIMU_R	1.5
LN_R	3.3
LOG_R	1.2
LOOP	1.5
LT_D	0.9
LT_R	0.9
MAX_D	0.9
MAX_R	1.4
MEMORY_D	0.9
MEMORY_R	1.1
MIN_D	0.7
MIN_R	1.3
MOD_D	1.5
MUL_D4	2.5
MUL_R4	2.7
MUL_XMV	2.8
MUX_D	1.2
MUX_R	0.9
NAND10	3.5
NE_D	0.9
NE_R	0.9
NEG	1.2
NEG_SPS	0.8
NLC_LZ	7.1
NLC_XMV	4.4
NLC_ZP	3.0
NOR10	3.2
OR_DYN	1.7
OR_SPS	1.3
OR10	2.6
R_TRGM	0.4
R_TRIG	0.4
REAL_DINT	3.0
REAL_SXMV	3.0
SIN_R	0.8
SPC_DEF	0.4

Element	Ticks
SPC_EXE	0.4
SPC_INFO	0.4
SPC_OUT	0.4
SPLIT_ACD	3.4
SPLIT_ACT	1.0
SPLIT_BSC	1.3
SPLIT_CMV	2.2
SPLIT_DEL	2.0
SPLIT_DPS	1.0
SPLIT_INS	0.5
SPLIT_Q	0.7
SPLIT_SPS	0.8
SPLIT_WYE	2.6
SPLIT_XMV	2.1
SQRT_R	0.6
SUB_D	1.3
SUB_R	1.6
SUB_XMV	2.4
SUBST_B	1.0
SUBST_BQ	1.5
SUBST_D	1.0
SUBST_R	1.0
SUBST_XQ	1.4
SXMV_REAL	3.0
TAN_R	1.1
TLONG	2.2
TOF	1.0
TON	1.1
TT	2.5
TSHORT	1.9
UINT_DINT	3.0
XOR2	2.6

A Appendix

A.1 Order Configurator and Order Options

Order Configurator

The order configurator assists you in the selection of SIPROTEC 5 products. The order configurator is a Web application that can be used with any browser. The order configurator can be used to configure complete devices or individual components, such as communication modules, expansion modules, or other accessories. At the end of the configuration process, the product code and a detailed presentation of the configuration result are provided. The product code unambiguously describes the selected product and also serves as an order number.

Ordering Options

The following ordering options are possible for SIPROTEC 5 products:

- Device
- Single part
- DIGSI 5
- Functional enhancement

NOTE

To order single parts in the order configurator, use the **Single part** link.

Individual parts are:

- Replacement base module
- Expansion module
- Plug-in module
- Sensors for arc protection
- Operation panel
- Terminal
- Accessories

A.2 Ordering Accessories

NOTE

To order terminals, terminal accessories, and mechanical accessories in the order configurator, use the **Single part link.**

Table A-1 Accessories

Group	Accessories
Terminal	Voltage terminal, terminal block, 14-pole
Terminal	Voltage input (power supply) Terminal block, 2-pole[1]
Terminal	Type A current terminal, 4 x protection (for modular devices)
Terminal	Type A current terminal, 3 x protection and 1 x measurement (for modular devices)
Terminal	Type A current terminal, 4 x measurement (for modular devices)
Terminal	Type B current terminal, 4 x protection (for non-modular devices)
Terminal	Type B current terminal, 3 x protection and 1 x measurement (for non-modular devices)
Terminal	2-pole cross connector for current terminal
Terminal	Terminal pair component IO118[1]
Terminal	Terminal kit only for IO230/231[1]
Terminal	2-pole cross connector for voltage terminal
Terminal	Cover for current terminal block
Terminal	Cover for voltage terminal block
Accessories	Cable, integrated operation panel 0.43 m
Accessories	Cable, detached operation panel 2.50 m
Accessories	Cable, detached operation panel 5.00 m
Accessories	Cable set COM link cable
Accessories	Cover plate for plug-in modules
Accessories	Set of angle brackets
Accessories	Labeling strips for LEDs/keypad
Accessories	Set of parts for mounting bracket 1/2
Accessories	Set of parts for mounting bracket 2/3
Accessories	Set of parts for mounting bracket 5/6
Accessories	Set of parts for mounting bracket 1/1
Accessories	Screw cover 1/3, type C11
Accessories	Screw cover 1/3, type C22
Accessories	Screw cover 1/6, type C21
Accessories	Bus termination plate
Accessories	Assembly frame for panel surface mounting for non-modular 7xx82 devices
Accessories	SDHC memory card for 7xx85

[1] Recommended tightening torque for fixing the terminal at the rear side: 0.3 Nm

Group	Accessories
Accessories	Battery holder
Accessories	Connecting cable for 2nd row
Accessories	Arc push buttons
Sensors for arc protection	Point sensor with line length of 3 m
Sensors for arc protection	Point sensor with line length of 4 m
Sensors for arc protection	Point sensor with line length of 5 m
Sensors for arc protection	Point sensor with line length of 10 m
Sensors for arc protection	Point sensor with line length of 15 m
Sensors for arc protection	Point sensor with line length of 20 m
Sensors for arc protection	Point sensor with line length of 35 m
Sensors for arc protection	Line sensor with line length of 5 m
Sensors for arc protection	Line sensor with line length of 10 m
Sensors for arc protection	Line sensor with line length of 20 m
Sensors for arc protection	Line sensor with line length of 30 m
Sensors for arc protection	Line sensor with line length of 40 m
Sensors for arc protection	Supply line for line sensors, length: 3 m
Sensors for arc protection	Supply line for line sensors, length: 5 m
Sensors for arc protection	Supply line for line sensors, length: 10 m

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A.3 Typographic and Symbol Conventions

The following typefaces are used to characterize parameters in the text:

Mode	Parameter name
_:11:1:2	Parameter address _ stands for the address combination from function group/function 661, for example, stands for the address of the setting parameter
Zero	Parameter state

The following symbols are used in drawings:

Icon	Description
_:661:41 P Stage blocked	Parameter
_:661:1 P Mode / off / on / test	Parameters with setting values The default setting is in the 1st position and displayed in italics
_:4661:2 P Operate & flt.rec. blocked / Dynam. setting list	Parameters with application-dependent setting values
_:4661:3 DP Threshold	Dynamic settings:
State control / State / Off / On / Test	State logic
Health / OK / Warning / Alarm	Health of a function, stage, or function block
_:661:81 >Block stage	External binary input signal with indication number
_:55 Pickup / General / A / B / C	External output signal with indication number and additional information
Pickup	External output signal without indication number
_:2451:300 f diff.	Measured output value

Icon	Description
51 Test mode	Binary input signal derived from an external output signal
Meas. volt. taken	Internal input signal
Block/reset stage	Internal output signal
Frequency	Analog input signal
	Invert/Block a logic element
AND	AND gate
OR	OR gate
XOR	XOR gate
	Negation
	Threshold stage exceeded
	Threshold stage exceeded with reset of input
	Threshold stage shortfall
	Threshold stage shortfall with reset of input
0 T	Threshold stage exceeded with dropout delay
0 T	Threshold stage exceeded with dropout delay and reset of input
0 T	Threshold stage shortfall with Dropout delay
0 T	Threshold stage shortfall with dropout delay and reset of input
a>b, a<b, a=b	Comparators
T 0	Pickup delay
0 T	Dropout delay
T1 T2	Pickup and dropout delay

Icon	Description
	Trigger the pulse of duration T with a positive signal edge
	Trigger the pulse of duration T with a negative signal edge
S R, R S, D C	SR-Flip-Flop, RS-Flip-Flop, D-Flip-Flop
	Characteristic curve
	Minimum operate time

A.4 Standard Variants for 7SJ82

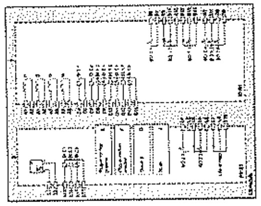

Figure A-1 Standard Variant Type U1

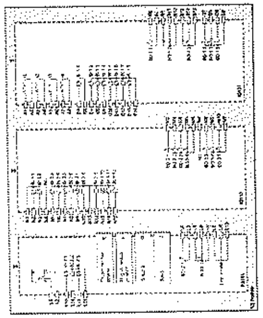

Figure A-2 Standard Variant Type U2

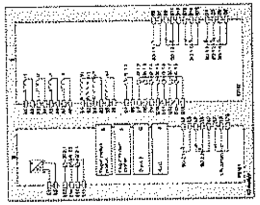

Figure A-3 Standard Variant Type U3

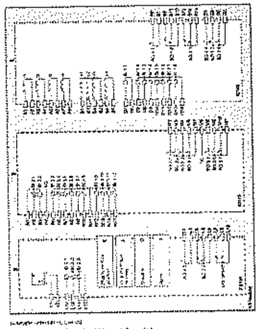

Figure A-4 Standard Variant Type U4

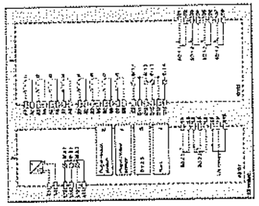

Figure A-5 Standard Variant Type U5

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A.5 Standard Variants for 7SJ85

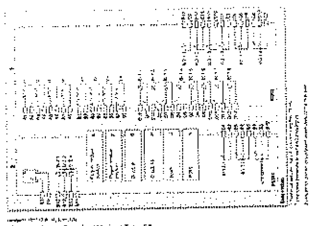


Figure A-6 Standard Variant Type S1

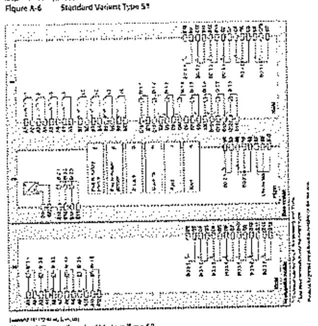


Figure A-7 Standard Variant Type S2

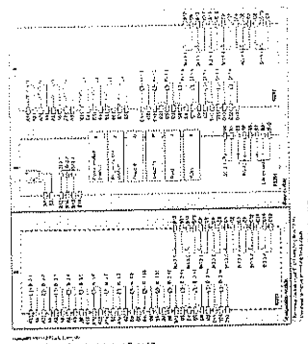


Figure A-8 Standard Variant Type S3

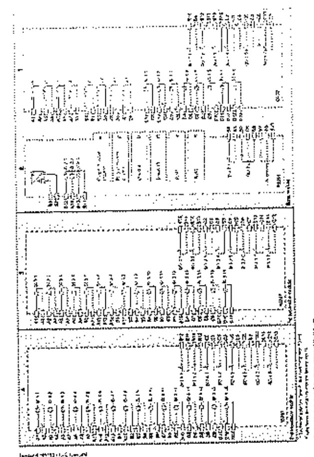


Figure A-9 Standard Variant Type S4

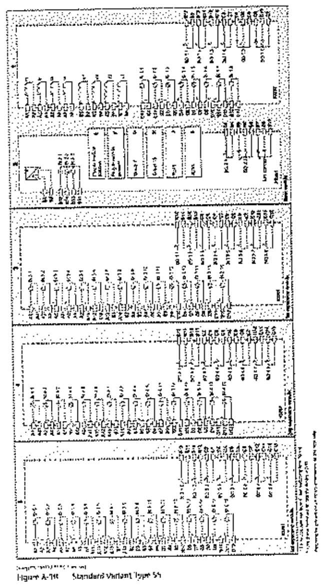


Figure A-10 Standard Variant Type S5

A.6 Current Transformer Requirements

The requirements for phase current transformers are usually determined by the overcurrent protection, particularly by the high-current element settings. Besides, there is a minimum requirement based on experience.

The recommendations are given according to the standard IEC 60044-1.

The standards IEC 60044-6, BS 3938 and ANSI/IEEE C 57.13 are referred to for converting the requirement into the knee-point voltage and other transformer classes.

Accuracy Limiting Factors

Table A-2 Effective and Rated Accuracy Limiting Factor

Required minimum effective accuracy limiting factor	$K_{ALF'} = \frac{I>>_{Pri}}{I_{rated,prim}}$ but at least 20	
	with	
	$K_{ALF'}$	Minimum effective accuracy limiting factor
	$I>>_{Pri}$	Primary pickup value of the high-current element
	$I_{rated,prim}$	Primary rated transformer current
Resulting rated accuracy limiting factor	$K_{ALF} = \frac{R_{BC} + R_{Ct}}{R_{BN} + R_{Ct}} \cdot K_{ALF'}$	
	with	
	K_{ALF}	Rated accuracy limiting factor
	R_{BC}	Connected burden (device and cables)
	R_{BN}	Rated burden
	R_{Ct}	Internal burden

Table A-3 Calculation Example According to IEC 60044-1

$I_{rated,sec} = 1$ A $K_{ALF'} = 20$ $R_{BC} = 0.6\ \Omega$ (device and cables) $R_{Ct} = 3\ \Omega$ $R_{BN} = 5\ \Omega$ (5 VA)	$K_{ALF} = \frac{0.6 + 3}{5 + 3} \cdot 20 = 9$ K_{ALF} set to 10, so that: 5P10, 5 VA
with $I_{rated,sec}$ = Secondary rated transformer current	

Class Conversion

Table A-4 Conversion into Other Classes

British Standard BS 3938	$V_k = \frac{(R_{Ct} + R_{BN}) \cdot I_{rated,sec}}{1.3} \cdot K_{ALF}$
ANSI/IEEE C 57.13, class C	$V_{s,max} = 20 \cdot I_{rated,sec} \cdot R_{BN} \cdot \frac{K_{ALF}}{20}$ $I_{rated,sec}$ = 5 A (typical value)

IEC 60044-6 (transient response), class TPS	$V_{al} = K \cdot K_{SSC} \cdot (R_{Ct} + R_{BN}) \cdot I_{rated,sec}$	
Classes TPX, TPY, TPZ	K ≈ 1 $K_{SSC} \approx K_{ALF}$ You can find a calculation example in the above section Accuracy Limiting Factors with $K_{SSC} \approx K_{ALF}$ T_p depending on power system and specified closing sequence	
	with	
	V_k	Knee-point voltage
	R_{Ct}	Internal burden
	R_{BN}	Rated burden
	$I_{rated,sec}$	Secondary rated transformer current
	K_{ALF}	Rated accuracy limiting factor
	$V_{s,max}$	Secondary terminal voltage at $20\ I_{rated,prim}$
	V_{al}	Secondary magnetization limit voltage
	K	Dimensioning factor
	K_{SSC}	Factor symmetric rated fault current
	T_p	Primary time constant

Cable Core Balance Current Transformer

The requirements to the cable core balance current transformer are determined by the function Sensitive ground-fault detection.

The recommendations are given according to the standards IEC 60044-1 and IEC 61869-2.

Table A-5 Requirements to the cable core balance current transformer according to IEC 60044-1 and IEC 61869-2

Transformation ratio, typical It may be necessary to select a different transformation ratio to suit the specific power system and thus the corresponding amount of the maximum ground fault current.	60 / 1
Accuracy limiting factor	FS = 10
Power	1 to 4 times the connected burden (device input plus leads)
Notes concerning the power: The burden of the sensitive ground-current input is very low (0.05 VA or 0.1 VA). Thus, an underburden of more than factor 4 is probable. In this case, clarify the suitability of the class accuracy concerning an impermissible underburden with the transformer manufacturer. If necessary, request the accuracy for the range from 0 VA to the rated burden. This specification is then outside the standard, but in practice, it is possible in most cases. (Relevant standard: IEC 61869-2, Chapter 5.6.201.6 Extended burden range. There, the range 1 VA to rated burden is specified for rated burdens smaller than 15 VA.)	

Table A-6 Minimum Required Class Accuracy Depending on Neutral Grounding and Function Operating Principle

Neutral Point	Isolated	Resonant-Grounded	High-Resistance Grounded
Function directional	Class 1	Class 1	Class 1

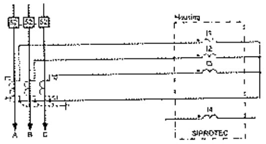
Function non directional	Class 3	Class 1	Class 3

NOTE

The class accuracy according to IEC 61869-2 below 5% I_{rated} (< 50 mA secondary) is not defined in general. For very sensitive directional measurements, Siemens recommends the classes 0.5S or 0.1S that define the class accuracy for an extended current range (up to 1% I_{rated}) (see chapter 5.6.201.5, IEC 61869-2).

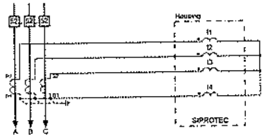
Another possibility is to correct the phase-angle error of the transformer on the device, if this error is known (see function description Sensitive ground-fault detection).

A.7 Connection Examples for Current Transformers



Current transformer 3-phase: connection = 3-phase

Figure A-11 Connection to a 3-Wire Current Transformer (Residual Current to be Calculated)

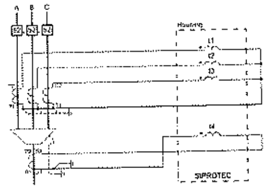


Current transformer 3-phase: connection = 3-phase + IN

Figure A-12 Connection to a 3-Wire Current Transformer and Measured Zero Sequence Current (Current in Common Return Path)

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 (I_N).

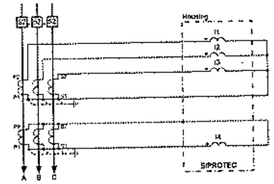


Current transformer 3-phase: connection = 3-phase + IN-separate

Figure A-13 Connection to a 3-Wire Current Transformer and Cable-Type Current Transformer for Sensitive Ground-Fault Detection

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N,sep}$).

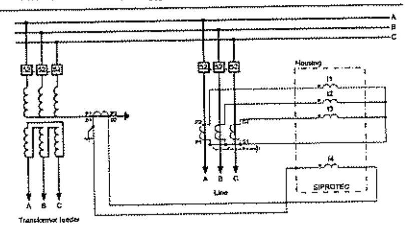


Current transformer 3-phase: connection = 3-phase + IN-separate

Figure A-14 Connection to a 3-Wire Current Transformer and Measured Ground Current from a Complete Holmgreen Connection

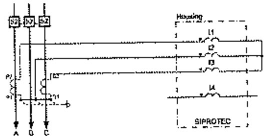
NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N,sep}$).



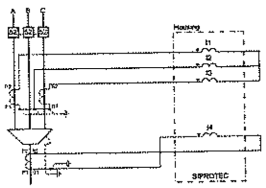
Current transformer 3-phase: connection = 3-phase
Current transformer 1-phase: connection = IN

Figure A-15 Connection to a 3-Wire Current Transformer and Measured Ground Current via the Neutral-Point Current Transformer of a Grounded Power Transformer



Current transformer 3-phase: connection = 3-phase, 2 primary CT

Figure A-16 Connection to a 2-Wire Current Transformer - for Isolated or Resonant-Grounded Systems Only

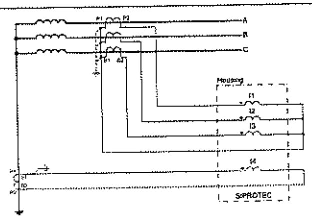


Current transformer 3-phase: connection = 3ph,2prim.CT + IN-sep

Figure A-17 Connection to a 2-Wire Current Transformer and Cable-Type Current Transformer for Sensitive Ground-Fault Detection - for Isolated or Resonant-Grounded Systems Only

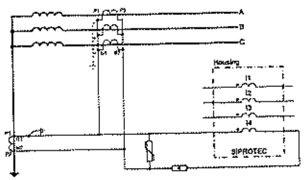
NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N,sep}$).



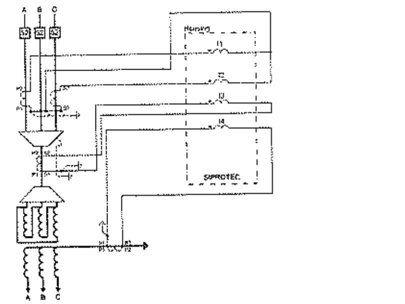
Current transformer 3-phase: connection = 3-phase
Current transformer 1-phase: connection = IN

Figure A-18 Connection to a 3-Wire Current Transformer and an Additional Current Transformer in the Neutral Point of a Grounded Power Transformer



Current transformer 1-phase, connection = Ix

Figure A-19 Current Transformer Connection for High-Impedance Differential Protection (for Example, a Power Transformer, in Preparation)



Current transformer 3-phase: connection = 2ph, 2p, CT + IN-sep

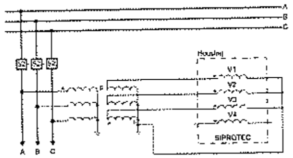
Current transformer 1-phase: connection = IX

Figure A-20 Connection to a 2-Phase Current Transformer and Cable-Type Current Transformer for Sensitive Ground-Fault Detection of the Line and Additional Sensitive Ground-Fault Detection via the Neutral-Point Current Transformer of a Grounded Power Transformer

NOTE

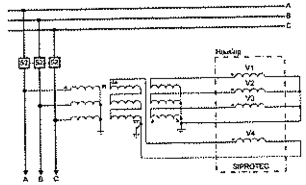
The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I2 (I_{sens})!

A.8 Connection Examples for Voltage Transformers for 7SJ85



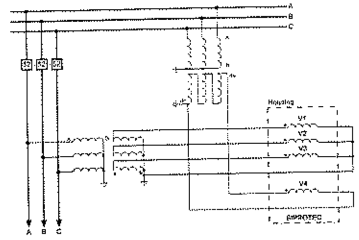
Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Figure A-21 Connection to 3 Star-Connected Voltage Transformers



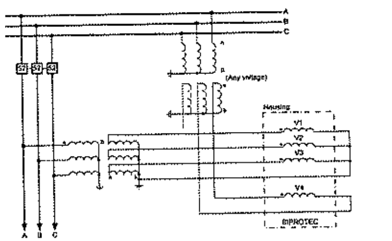
Voltage transformer 3-phase: connection = 3 ph-to-gnd volt. + VN

Figure A-22 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding



Voltage transformer 3-phase: connection = 3 ph-to-gnd volt. + VN

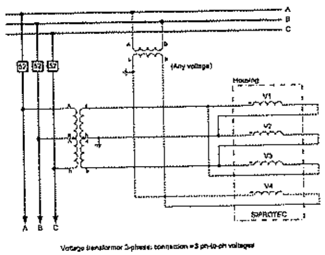
Figure A-23 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer (for example, Busbar)



Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

Figure A-24 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)



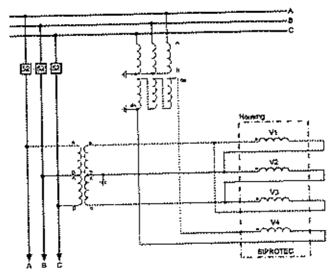
Voltage transformer 3-phase: connection = 3 ph-to-ph voltages

Voltage transformer 1-phase: connection = VAB

Figure A-25 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer

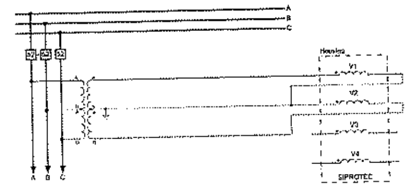
NOTE

When using the connection type 3-phase-to-phase voltage, the zero-sequence voltage cannot be detected.



Voltage transformer 3-phase: connection = 3 ph-to-ph volt. + VN

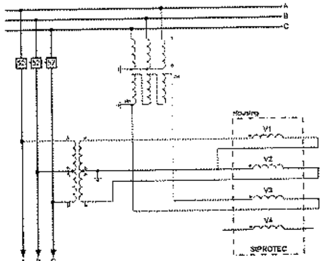
Figure A-26 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



Voltage transformer 3-phase: connection = 2 ph-to-ph voltages

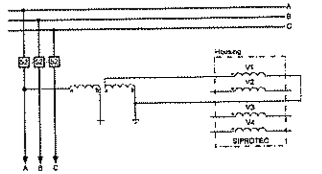
Phase voltages = VAB VBC

Figure A-27 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)



Voltage transformer 3-phase: connection = 2 ph-to-ph volt. + VN
Phase voltages = VAB, VBC

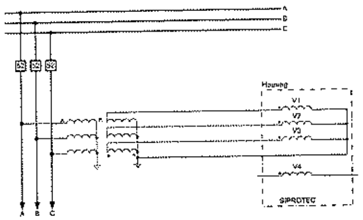
Figure A-28 Connection to V Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



Voltage transformer 1-phase: connection = VA

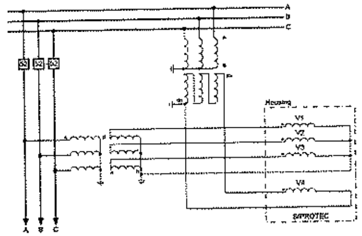
Figure A-29 Connection to a 1-Pole Insulated Voltage Transformer (Phase-to-Ground Voltage)

A.9 Connection Examples for Voltage Transformers for 7SJ82



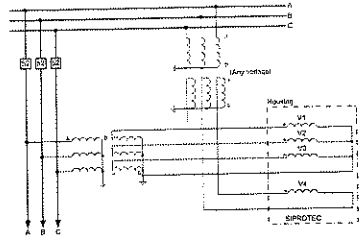
Voltage transformer 3-phase: connection = 3 phase-to-ground volt.

Figure A-30 Connection to 3 Star-Connected Voltage Transformers



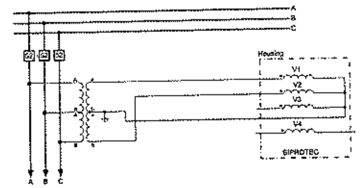
Voltage transformer 3-phase: connection = 3 phase-to-ground volt. + VN

Figure A-31 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer



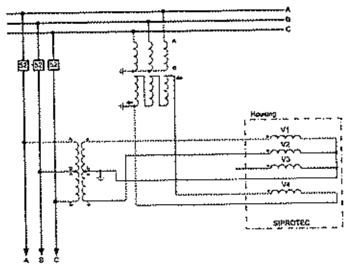
Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages
Voltage transformer 1-phase: connection = VAB

Figure A-32 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)



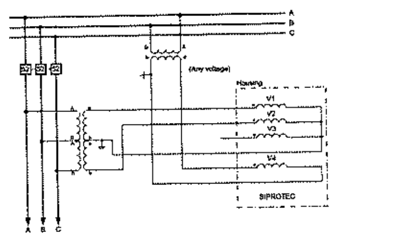
Voltage transformer 3-phase: connection = 2 ph-to-ph voltages
Phase voltages = VAB, VCB

Figure A-33 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)



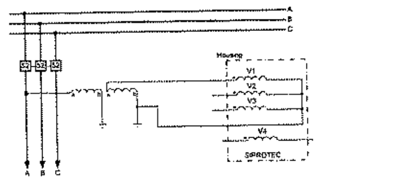
Voltage transformer 3-phase: connection = 2 ph-to-ph volt. + VN
Phase voltages = VAB, VCB

Figure A-34 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



Voltage transformer 3-phase: connection = 2 ph-to-ph voltages
Phase voltages = VAB, VCB
Voltage transformer 1-phase: connection = VAB

Figure A-35 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchronization Applications)



Voltage transformer 1-phase: connection = VA

Figure A-36 Connection to a 1-Pole Insulated Voltage Transformer (Phase-to-Ground Voltage)

A.10 Prerouting 7SJ82/85 General

Meaning of the abbreviations in DIGSI, see 8.2.2.4 Connection Variants of the Circuit Breaker.

Binary Inputs

Table A-7 Default Binary Inputs, Using the Example of Overcurrent Protection

Binary Input	Signal	Number	Signal Type	Configuration
BI1	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	OH
BI2	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	CH
BI3	Disconnector 1:Circuit break.:Position	601.5401.58	DPC	OH
BI4	Disconnector 1:Circuit break.:Position	601.5401.58	DPC	CH
BI5	Disconnector 2:Circuit break.:Position	602.5401.58	DPC	OH
BI6	Disconnector 2:Circuit break.:Position	602.5401.58	DPC	CH
BI7	Disconnector 3:Circuit break.:Position	603.5401.58	DPC	OH
BI8	Disconnector 3:Circuit break.:Position	603.5401.58	DPC	CH
BI9	Power system:Meas. point V-3ph 1:VT miniature CB:>Open	11.941.2641.500	SPS	H

Binary Outputs

Table A-8 Default Output Relays, Using the Example of Overcurrent Protection

Binary Output	Signal	Number	Signal Type	Configuration
BO1	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	U
BO2	Circuit breaker 1:Circuit break.:Close command	201.4261.301	SPS	X
BO3	Disconnector 1:Disconnector:Open command	601.5401.300	SPS	X
BO4	Disconnector 1:Disconnector:Close command	601.5401.301	SPS	X
BO5	Disconnector 2:Disconnector:Open command	602.5401.300	SPS	X
BO6	Disconnector 2:Disconnector:Close command	602.5401.301	SPS	X
BO7	Disconnector 3:Disconnector:Open command	603.5401.300	SPS	X
BO8	Disconnector 3:Disconnector:Close command	603.5401.301	SPS	X

Function Keys

Table A-9 Default Setting Function Key Using the Example of Overcurrent Protection

Function Key	Signal	Number	Signal Type	Configuration
F-key1	Main menu:Logs:Operational log			X
F-key2	Main menu:Measurements:VI 3ph 1:Operational values			X
F-key3	Main menu:Logs:Fault log			X

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Light-Emitting Diodes

Table A-10 Default LED Displays, Using the Example of Overcurrent Protection

LEDs	Signal	Number	Signal Type	Configura-tion
LED1	VI 3ph 1:Group indicat.:Pickup:phs A		SPS	NT
LED2	VI 3ph 1:Group indicat.:Pickup:phs B		SPS	NT
LED3	VI 3ph 1:Group indicat.:Pickup:phs C		SPS	NT
LED4	VI 3ph 1:Group indicat.:Pickup:phs gnd		SPS	NT
LED5	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	L
LED15	Alarm handling:Group warning	5971.301	SPS	[illegible]
LED16	Device:Process mode inactive		SPS	[illegible]

A.11 Prerouting 7SJ82/85 Capacitor Bank Applications

Meaning of the abbreviations in DIGSI, see 2.7.1 Connection Variants of the Circuit Breaker

Binary Inputs

Table A-11 Default Binary Inputs, Using the Example of Overcurrent Protection

Binary input	Signal	Number	Signal type	Configuration
BI1	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	OH
BI2	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	CH

Binary Outputs

Table A-12 Default Output Relays, Using the Example of Overcurrent Protection

Binary output	Signal	Number	Signal type	Configuration
BO1	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	U
BO2	Circuit breaker 1:Circuit break.:Close command	201.4261.301	SPS	X

Function Keys

Table A-13 Default Setting Function Key Using the Example of Overcurrent Protection

Function key	Signal	Number	Signal type	Configu-ration
F-key1	Main menu:Logs:Operational log			X
F-key2	Main menu:Measurements:Capacitor bank 1:Operational values			X
F-key3	Main menu:Logs:Fault log			X

Light-Emitting Diodes

Table A-14 Default LED Displays, Using the Example of Overcurrent Protection

LEDs	Signal	Number	Signal type	Configura-tion
LED1	Capacitor bank 1:Group indicat.:Pickup:phs A		SPS	NT
LED2	Capacitor bank 1:Group indicat.:Pickup:phs B		SPS	NT

LEDs	Signal	Number	Signal type	Configura-tion
LED3	Capacitor bank 1:Group indicat.:Pickup:phs C		SPS	NT
LED4	Capacitor bank 1:Group indicat.:Pickup:phs gnd		SPS	NT
LED5	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	L
LED15	Alarm handling:Group warning	5971.301	SPS	U
LED16	Device:Process mode inactive		SPS	U

Glossary

ACD

IEC 61850 data type: Directional protection activation information

ACK

Data transfer acknowledgment

ACT

IEC 61850 data type: Protection activation information

APC

Controllable analog set point information

ASDU

ASDU stands for Application Service Data Unit. An ASDU can consist of one or more identical information objects. A sequence of the same information elements, for example measured values, is identified by the address of the information object. The address of the information object defines the associated address of the first information element of the sequence. A consecutive number identifies the subsequent information elements. The number builds on this address in integral increments (1).

BAC

Binary Controlled Analog Process Value

Back-up battery

The back-up battery ensures that specified data areas, flags, times and counters are kept retentive.

Bay Controller

Bay controllers are devices with control and monitoring functions without protection functions.

BCR

IEC 61850 data type: Binary counter reading

Best master clock algorithm

A PTP network contains communicating clocks. With the best master clock algorithm (BMC), the device indicating the most precise time is determined. This device is used as a reference clock and is designated as grandmaster. If the network topology is changed, the BMC algorithm is executed again on network segments that are possibly disconnected from the grandmaster. If a participating device is a master and a slave, it is called a boundary clock.

Big-endian

Big-endian and little-endian describe the order in which a sequence of bytes is stored. In big-endian systems, the most significant byte is stored at the lowest storage address. In little-endian systems, the most significant byte is stored at the highest storage address.

Binary Controlled Analog Process Value

The data type BAC represents a command with or without feedback. The BAC is used for example for the control of an arc suppression coil. The commands Higher, Lower, and Stop are possible. The feedback from the process is an analog value.

Binary Controlled Step Position

The data type BSC can, for example, be used to control a transformer tap changer. The commands up, down can be given.

Bit pattern indication

A bit pattern indication is a processing function, with the help of which adjacent numerical process information can be logged coherently and processed further in parallel via multiple inputs. The bit pattern indication can be selected as 1, 2, 3 or 4 bytes.

BMC

See best master clock algorithm

Boundary Clock

The Precision Time Protocol knows different types of clocks: an ordinary clock (abbreviation: OC), a boundary clock (BC), and a transparent clock (TC). The boundary clock transports time information over a network limit, for example, in a router connecting different switched networks: As a slave, the clock of the router receives the time information and transmits this further on as a master.

BRCB

Buffered Report Control Block

BSC

Binary Controlled Step Position

Buffered Report Control Block

Buffered Report Control Block (BRCB) is a form of report controlling. Internal events trigger the immediate sending of reports or saving of events for the transfer. Data values cannot therefore be lost on account of transport flow control conditions or connection interruptions. BRCB provides the functionality SOE (See Sequence of Events).

CB

Circuit breaker

CDC

Common Data Class

CFC

Continuous Function Chart

Chatter Blocking

A rapidly intermittent input (for example, owing to a relay contact fault) is disconnected after a parameterizable monitoring time and therefore cannot generate any more signal changes. The function prevents the system from overloading in the event of an error.

CID

Configured IED Description

CMV

Complex measured value

Combination Device

Combination devices are bay units with protection functions and with feeder mimic diagram.

Common Data Class

Generic term for a data class according to the IEC 61850 model.

Communication branch

A communication branch corresponds to the configuration of 1 to n participants communicating via a joint bus.

Configured IED Description

A Configured IED Description (CID) is a file for data exchange between the IED Configuration Tool and the IED itself.

Container

If an object contains other objects, this is referred to as a container. The object Folder for example is such a container.

Continuous Function Chart

The Continuous Function Chart (CFC) is a programming language. It is used for programmable logic controllers. The programming language Continuous Function Chart is not defined in the standard IEC 61131-3, but represents a current extension of IEC programming environments. CFC is a graphic programming language. Function blocks are linked to one another. This represents an essential difference from conventional programming languages, where sequences of commands are entered.

Control display

The control display becomes visible for devices with a large display after pressing the Control key. The diagram contains the switching devices to be controlled in the feeder. The control display serves for implementing switching operations. Specification of this diagram forms part of configuring.

Controllable Integer Status

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

Controller

The controller initiates the IO data communication.

CRC

Cyclic redundancy check

Data type

The data type is a value set of a data object, together with the operations allowed on this value set. A data type contains a classification of a data element, such as the determination whether it consists of integers, letters, or similar.

Data unit

Information item with a joint transmission source. Abbreviation: DU = Data Unit

Data window

The right area of the project window visualizes the contents of the area selected in the navigation window. The data window contains for example, indications or measured values of the information lists or the function selection for parametrization of the device.

DCF

Device Configuration File: Device parameterization

DCF77

The precise official time is determined in Germany by the Physikalisch-Technische Bundesanstalt PTB in Braunschweig. The atomic clock unit of the PTB transmits this time via the long-wave time signal transmitter in Mainflingen near Frankfurt/Main. The emitted time signal can be received within a radius of approx. 1500 km from Frankfurt/Main.

DCP

Discovery and Basic Configuration Protocol

DDD

SIPROTEC 5 device driver (DIGSI 5 Device Driver)

DEL

Phase-to-phase related measurements of a 3-phase system

Device 5 Export Format

DEX5

Device Container

In the component view, all SIPROTEC devices are subordinate to an object of the device container type. This object is also a special object from the DIGSI 5 Manager. However, as there is no component view in the DIGSI 5 Manager, this object only becomes visible in conjunction with STEP 7.

DEX5

Device 5 Export Format
You can archive the data from an individual SIPROTEC 5 device in DEX5 format.

DHCP

Dynamic Host Configuration Protocol

DIGDNP

DIGSI 5 protocol settings for DNP3
File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGMOD

DIGSI 5 protocol settings for Modbus TCP
File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGSI 5 Display Pages

You can archive individual or all display pages of a SIPROTEC 5 device in DSPS format. You can also use this format to exchange display pages between SIPROTEC 5 devices. The DSPS format is based on XML.

DIGSI 5 protocol settings for DNP3

If the DNP3 protocol is configured for a system interface, you can export the protocol settings in DIGDNP format. The DIGDNP format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for IEC 60870-5-103

If the IEC 60870-5-103 protocol is configured for a system interface, you can export the protocol settings in DIGT103 format. The DIGT103 format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for IEC 60870-5-104

If the IEC 60870-5-104 protocol is configured for a system interface, you can export the protocol settings in DIGT104 format. The DIGT104 format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for Modbus TCP

If the Modbus TCP protocol is configured for a system interface, you can export the protocol settings in DIGMOD format. The DIGMOD format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 Test Sequences

You can archive individual or all test sequences of a SIPROTEC 5 device in SEQS format. You can also use this format to exchange test sequences between SIPROTEC 5 devices. The SEQS format is based on XML.

DIGSI

Configuration software for SIPROTEC

DIGT103

DIGSI 5 protocol settings for IEC 60870-5-103
File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGT104

DIGSI 5 protocol settings for IEC 60870-5-104
File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

Discovery and Basic Configuration Protocol

The DCP protocol is used to detect devices without IP addresses and to assign addresses to these devices.

DNP3

DNP3 is a communications standard for telecontrol engineering. DNP3 is used as a general transmission protocol between control systems and substations and between bay devices and the systems control.

Double Command

Double commands (DPC – Double Point Control) are process outputs which visualize 4 process states at 2 outputs: 2 defined states (for example, On/Off) and 2 undefined states (for example, disturbed positions).

Double-point indication

Double-point indications (DPS – Double point status) are process indications which visualize 4 process states at 2 inputs: 3 defined states (for example, On/Off and disturbed position) and 1 undefined state (00).

DPC

IEC 61850 data type: Double Point Control

DPS

IEC 61850 data type: Double-point status

Drag and drop

Copying, moving, and linking function, used in graphic user interfaces. The mouse is used to highlight and hold objects and then move them from one data area to another.

DSPS

DIGSI 5 Display Pages

DU

Data unit

Dynamic Host Configuration Protocol

In order to configure PCs automatically, centralized and uniformly in a TCP/IP network, a dynamic assignment of IP addresses is used. DHCP is used. The system administrator determines how the IP addresses are to be assigned and specifies the time lapse over which they are assigned. DHCP is defined in the Internet standards RFC 2131 (03/97) and RFC 2241 (11/97).
For SIPROTEC 5, a device can also be assigned an IP address via DIGSI via DHCP.

ELCAD

Electrical CAD

Electrical CAD

You can import the topology information contained in an ELCAD file into a project and use it as the basis for a single-line configuration. The other information contained in the ELCAD file is not included in this process.

Electromagnetic Compatibility

Electromagnetic compatibility (EMC) means that an item of electrical equipment functions without error in a specified environment. The environment is not influenced in any impermissible way here.

ENC

Enumerated Status Controllable

ENS

Enumerated Status

ESD Protection

The ESD protection is the entirety of all means and measures for the protection of electrostatic-sensitive devices.

Far End Fault Indication

Far End Fault Indication (FEFI) is a special setting of switches. It is always only possible to log a line interruption on the receive line. If a line interruption is detected, the link status of the line is changed. The status change leads to deletion of the MAC address assigned to the port in the switch. However, outage of the receive line from the aspect of the switch can only be detected in the receiver, that is, by the switch. The receiver then immediately blocks the transmit line and signals the connection failure to the other device. The FEFI setting in the switch triggers detection of the error on the receive line of the switch.

FEFI

Far End Fault Indication

FG

Function group

Fleeting Indication

Fleeting indications are single-point indications present for a very short time, in which only the coming of the process signal is logged and further processed time-correctly.

Floating

Floating means that a free potential not connected to ground is generated. Therefore no current flows through the body to ground in the event of touching.

Folder

This object type helps when structuring a project hierarchically.

Function group

Functions are brought together into function groups (FG). The assignment of functions to current and/or voltage transformers (assignment of functions to measuring points), the information exchange between the function groups via interfaces as well as the generation of group indications are important for this bringing together.

General Interrogation

The state of all process inputs, of the status, and of the error image are scanned on system startup. This information is used to update the system-side process image. Likewise, the current process state can be interrogated after data loss with a general interrogation (GA).

General Station Description Mark-up Language

GSDML is an XML-based description language for creating a GSD file.

Generic Object-Oriented Substation Event

GOOSE. Protocol of IEC 61850 for communication between bay units.

GI

General Interrogation

GIN

Generic Identification Number

GOOSE

Generic Object-Oriented Substation Event

Ground

The conductive ground whose electric potential can be set equal to 0 at every point. In the area of grounding conductors, the ground can have a potential diverging from 0. The term reference ground is also used for this situation.

Grounding

The grounding is the entirety of all means and measuring for grounding.

GSDML

General Station Description Mark-up Language

Hierarchy Level

In a structure with superordinate and subordinate objects, a hierarchy level is a level of equal-ranking objects.

High Availability Seamless Redundancy Protocol

Like PRP (Parallel Redundancy Protocol), HSR (High Availability Seamless Redundancy Protocol) is specified in IEC 62439-3. Both protocols offer redundancy without switching time.
The principal function can be found in the definition of PRP. With PRP, the same indication is sent via 2 separated networks. In contrast to this, in the case of HSR the indication is sent twice in the 2 directions of the ring. The recipient receives it correspondingly via 2 paths in the ring, takes the 1st message and discards the 2nd (see PRP).
Whereas NO indications are forwarded in the end device in the case of PRP, a switch function is installed in the HSR node. Thus, the HSR node forwards indication in the ring that are not directed at it.
In order to avoid circular messages in the ring, corresponding mechanisms are defined in the case of HSR.
SAN (Single Attached Node) end devices can only be connected with the aid of a REDBOX in the case of HSR. PRP systems and HSR systems can be coupled redundantly with 2 REDBOXES.

HMI

Human Machine Interface

HSR

High Availability Seamless Redundancy Protocol

HV bay description

The HV project description file contains data concerning which bays are present within a ModPara project. The actual bay information is saved for each bay in an HV bay description file. Within the HV project description file, each bay receives an HV bay description file through a reference to the file name.

HV Project Description

If the configuring and parameterization of PCUs and submodules is completed with ModPara, all the data will be exported. The data is distributed to several files during this process. A file contains data on the basic project structure. This typically includes information on which bays are present within this project. This file is designated as an HV project description file.

ICD

IED Capability Description

IEC

International Electrotechnical Commission

IEC 60870-5-103

International standard protocol for communication with IEDs (especially protective equipment). Many protection relays, bay devices, bay controllers and measurement acquisition devices use the IEC 60870-5-103 protocol to communicate with the SICAM system.

IEC 60870-5-104

Internationally standardized telecontrol protocol. Transmission protocol based on IEC 60870-5-101 for the connection of the substation control level to the telecontrol center using TCP/IP via a Wide Area Network (WAN) connection.

IEC 60870-5-104 is also used for the communication with IEDs.

IEC 61850

IEC 61850 is an international standard for consistent communication in substations. This standard defines the communication amongst devices in substations and the related system requirements. All substation automation functions as well as engineering functions are supported. IEC 61850 can also be transferred to automation systems in other applications, for example, for the control and monitoring of distributed power generation.

IEC address

A unique IEC address must be assigned to each SIPROTEC device within an IEC bus. A total of 254 IEC addresses per IEC bus are available.

IEC communication branch

Within an IEC communication branch, the participants communicate on the basis of the protocol IEC 60870-5-103 via an IEC bus.

IED Capability Description

Data exchange from the IED configuration software (DIGSI) to the system configurator. This file describes the performance properties of an IED.

IEEE 1588

Time-synchronization protocol according to IEEE Std 1588-2008: Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (IEEE 1588 v2) and IEEE Std C37.238 2011: IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications (Power Profile).

IID

Instantiated IED Description

INC

Controllable Integer Status

Initialization string

An initialization string consists of a series of modem-specific commands. If the modem is initialized, these commands are transferred to the modem. The commands can force definite settings for the modem, for example.

Input Data/Input Direction

Data is sent from the protocol slave to the protocol master.

INS

Integer Status

Instantiated IED Description

Files in IID format are ICD files adapted for the concrete application in the project. This format is mainly suitable for exchanging data between DIGSI 5 and an external system configurator or also a substation automation system such as SICAM PAS. The ICD format uses SCL as the description language for this purpose.

International Electrotechnical Commission

IEC

Internet protocol

An Internet protocol (IP) enables the connection of participants which are positioned in different networks.

IO

Input, Output

IO Provider Status

The provider (sender) of an IO data element uses this to signal the status (good/bad with error location).

IOPS

IO Provider Status

IP

Internet protocol

IPv4

Internet protocol version 4

ISC

Integer Step Controlled Position Information

LAN

Local Area Network

Link Address

The link address indicates the address of a SIPROTEC device.

Link Layer Discovery Protocol

The Link Layer Discovery Protocol supplies the basis for topology detection and for determination of the configuration.

List view

The right area of the project window displays the names and symbols of the objects which are within a container selected in the tree view. As the visualization is in the form of a list, this area is also referred to as list view.

LLDP

Link Layer Discovery Protocol

Local Area Network

A Local Area Network (LAN) is a regional, local PC network. The PCs are all equipped with a network interface card and work with one another via data exchange. The LAN requires an operating system on each PC and standardized data transport software. The operating systems can be different, as can the data transport software, but both must support a common transmission protocol (→ TCP/IP protocols), so that all PCs can exchange data with one another.

LSB

Least Significant Bit

MAC address

The MAC address (Media Access Control) is the hardware address of each single system adapter. With the MAC address, the device can be identified unambiguously in the system.

Management Information Base

A Management Information Base (MIB) is a database which saves information and statistics concerning each device in a network continuously. The performance of each device can be monitored with this information and statistics. In this way, it can also be ensured that all devices in the network function properly. MIBs are used with SNMP.

Manufacturing Message Specification

The standard Manufacturing Message Specification (MMS) serves for data exchange. The standard is used for the transmission protocols IEC 61850 and IEC 60870-6 TASE.2.

Measured Value

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

Metered value

Metered values are a processing function, used to determine the total number of discrete similar events (counting pulses), for example, as integral over a time span. In the power supply utility field, electrical energy is often recorded as a metered value (energy import/delivery, energy transport).

MIB

Management Information Base

MICS

Model Implementation Conformance Statement

MMS

Manufacturing Message Specification

Modbus

The Modbus protocol is a communication protocol. It is based on a Master/Slave or Client/Server architecture.

Model Implementation Conformance Statement

Model Implementation Conformance Statement (see MICS)

The Model Implementation Conformance Statement describes in detail the standard data object models that are supported by the system or by the device.

Modem

Modem profiles for a modem connection are saved in this object type.

Modem Connection

This object type contains information on the two partners of a modem connection, local modem and remote modem.

Modem Profile

A modem profile comprises the name of the profile, a modem driver and optionally several initialization commands as well as a participant address. You can create multiple modem profiles for a physical modem. For this, link different initialization commands or participant addresses with a modem driver and its properties, and save these under various names.

Module

Self-contained unit at the device level. This can be a real module or a functional unit of the device.

MSB

Most Significant Bit

MV

Data type Measured Value

NACK

Negative acknowledgment

Navigation Window

Left area of the project window, which visualizes the names and symbols of all containers of a project in the form of a hierarchical tree structure.

Object

Each element of a project structure is designated as an object in DIGSI 5.

Object Property

Each object has properties. These can on the one hand be general properties that are common to several objects. Otherwise, an object can also have object-specific properties.

Offline

If there is no communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is offline. The PC program executes in Offline mode.

Online

If there is a communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is online. The PC program executes in Online mode.

Optical Switch Module

An Optical Switch Module (OSM) is a process for switching over switches in Ethernet networks that are ring-shaped in structure. OSM is a proprietary process from Siemens, which later became standard under the term MRP. OSM is integrated in the optical Ethernet module EN100-O. OSM is hardly used in IEC 61850 networks. RSTP is used there, this having become established as an international standard.

OSM

Optical Switch Module

Output data/Output direction

Data is sent from the protocol master to the protocol slave.

Parallel Redundancy Protocol

Parallel Redundancy Protocol (PRP) is a redundancy protocol for Ethernet networks that is specified in IEC 62439-3. Unlike conventional redundancy procedures, such as RSTP (Rapid Spanning Tree Protocol, IEEE 802.1D-2004), PRP offers uninterruptible switching, which avoids any down time in the event of a fault, and thus the highest availability.

PRP is based on the following approach: The redundancy procedure is generated in the end device itself. The principle is simple: The redundant end device has 2 Ethernet interfaces with the same address (DAN, Double Attached Node). Now, the same indication is sent twice, in the case of PRP (parallel) to 2 separate networks, and uniquely marks both with a sequence number. The recipient takes the information that it receives first, stores its ID based on the source address and the sequence number in a duplicate filter and thus recognizes the 2nd, redundant information. This redundant information is then discarded. If the 1st indication is missing, the 2nd indication with the same content comes via the other network. This redundancy avoids a switching procedure in the network and is thus interruption-free. The end device forwards no messages to the other network. Since the process is realized in the Ethernet layer (same MAC address), it is transparent and usable for all Ethernet payload protocols (IEC 61850, DNP, other TCP/IP based protocols). In addition, it is possible to use one of the 2 networks for the transmission of non-redundant messages.

There are 2 versions of PRP: PRP-0 and its successor PRP-1. Siemens implements PRP-1.

Parameterization

Comprehensive term for all setting work on the device. You can parameterize the protection functions with DIGSI 5 or sometimes also directly on the device.

Parameter set

The parameter set is the entirety of all parameters that can be set for a SIPROTEC device.

Participant address

A participant address consists of the name of the participant, the international dialing code, the local dialing code and the participant-specific telephone number.

PICS

Protocol Implementation Conformance Statement

PLC

See Programmable Logic Controller

PLC

Programmable Logic Controller

PROFIBUS

PROcess FIeld BUS, German Process and Fieldbus standard (EN 50170). The standard specifies the functional, electrical and mechanical characteristics for a bit-serial fieldbus.

PROFIBUS Address

A unique PROFIBUS address must be assigned to each SIPROTEC device within a PROFIBUS network. A total of 254 PROFIBUS addresses per PROFIBUS network are available.

Profile_ID

A Profile_ID in combination with an API uniquely identifies the access and the behavior of an application

PROFINET IO

PROFINET is an open Industrial Ethernet Standard from PROFIBUS for the automation.

Programmable Logic

The programmable logic is a function in Siemens devices or station controllers, enabling user-specific functionality in the form of a program. This logic component can be programmed by various methods: CFC (= Continuous Function Chart) is one of these. SFC (Sequential Function Chart) and ST (Structured Text) are others.

Programmable Logic Controller

Programmable logic controllers (PLC) are electronic controllers whose function is saved as a program in the control unit. The construction and wiring of the device do not therefore depend on the function of the control. The programmable logic controller has the structure of a computer; it consists of CPU with memory, input/output groups (for example, DI, AI, CO, CI), power supply (PS) and rack (with bus system). The peripherals and programming language are oriented towards the circumstances of the control system.

Programmable Logic Module

Modules are parts of the user program delimited by their function, structure and intended use.

Project

In terms of content, a project is the replication of a real energy supply system. In graphic terms, a project is represented as a number of objects which are incorporated in a hierarchical structure. Physically, a project consists of a series of directories and files containing project data.

Project tree

The Project tree is used to display a data structure. This data structure represents the content of the project and is created by a Generic Browser.

Protection communication

Protection communication includes all functionalities necessary for data exchange via the protection interface. Protection communication is created automatically during configuration of communication channels.

Protection Device

A protection device detects erroneous states in distribution networks, taking into account various criteria, such as error distance, error direction or fault direction, triggering a disconnection of the defective network section.

Protocol Implementation Conformance Statement

The performance properties of the system to be tested are summarized in the report on the conformity of implementation of a protocol (PICS = Protocol Implementation Conformance Statement).

PRP

Parallel Redundancy Protocol

Rapid Spanning Tree Protocol

The Rapid Spanning Tree Protocol (RSTP) is a standardized redundancy process with a short response time. In the Spanning Tree Protocol (STP protocol), structuring times in the multidigit second range apply in the case of a reorganization of the network structure. These times are reduced to several 100 milliseconds for RSTP.

Real Time

Real time

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RedBox

Redundancy Box

The RedBox is used for the redundant connection of devices with only one interface to both the LAN A and the LAN B PRP network. The RedBox is a DAN (Double Attached Node) and operates as a proxy for the devices connected to it (VDANs). The RedBox has its own IP address in order to be able to configure, manage, and monitor it.

Relay information by OMICRON

Files in RIO format can be used to exchange data between test systems from the OMICRON company and any other project-protection planning system. With DIGSI 5, you can export different settings from protection functions in RIO format, which the OMICRON test equipment 7UP15 can then continue to process. The relevant settings are described in the Test equipment manual.

RIO

Data format Relay Information by OMICRON

RSTP

Rapid Spanning Tree Protocol

SAN

Single Attached Node

A SAN is a non-redundant node in the PRP network. It is only connected with one port to one network (LAN A or LAN B). It can only communicate with nodes in the connected network. Via a RedBox, devices with only one connection can be redundantly connected to the 2 LAN A and LAN B networks. In order to obtain symmetrical LAN A and LAN B networks, Siemens recommends avoiding SANs and to connect the devices either via a RedBox or in a separate network without PRP support.

SBO

Select before operate

SC

See Single Command

SCD

See Substation Configuration Description

SCL

Substation Configuration Description Language

SED

System Exchange Description

SEQ

Data type Sequence

SEQS

DIGSI 5 Test Sequences

Sequence of Events

Acronym: SOE. An ordered, time-stamped log of status changes at binary inputs (also referred to as state inputs). SOE is used to restore or analyze the performance, or an electrical power system itself, over a certain period of time.

Service interface

Device interface for interfacing DIGSI 5 (for example, through a modem)

SICAM SAS

Substation Automation System – Modularly structured station control system, based on the substation controller SICAM SC and the SICAM WinCC operator control and monitoring system.

SICAM WinCC

The operator control and monitoring system SICAM WinCC graphically displays the state of your network. SICAM WinCC visualizes alarms and messages, archives the network data, provides the option of intervening manually in the process and manages the system rights of the individual employees.

SIM

Simulation data format for single/multiple devices

Simple Network Management Protocol

The Simple Network Management Protocol (SNMP) is an Internet standard protocol and serves for the administration of nodes in an IP network.

Simple Network Time Protocol

The Simple Network Time Protocol (SNTP) is a protocol for the synchronization of clocks via the Internet. With SNTP, client computers can synchronize their clocks via the Internet with a time server.

Simulation data format for single/multiple devices

You can export the simulation-related files of a SIPROTEC 5 device in the SIM format. This new functionality in DIGSI 5 provides the ability to export the simulation data and simulate all the devices in the DIGSI 5 project for test and commissioning needs. The simulation is achieved by importing the simulation file into a signal processing and automation system which will then simulate the device/devices with the process data as in a real-time system. This feature also ensures the testing of a device for various real-time system conditions.

Single Command

Single commands (SPC - Single Point Control) are process outputs which visualize 2 process states (for example, On/Off) at an output.

Single-line diagram

A single-line diagram (SLD) is a simplified electric overview of the switchgear. Only 1 phase is shown instead of all 3 phases of a line. Therefore, the diagram is called single-line.

Single-Line Editor

A Single-Line Editor contains a catalog of topological components to create a single-line diagram. The customer may use the single-line elements to configure the topological view of his substation.

Single-point indication

Single-point indications (SPS – Single point status) are process indications which visualize 2 process states (for example, On/Off) at an input.

SIPROTEC 5 device

This object type represents a real SIPROTEC device with all the contained setting values and process data.

SIPROTEC

The registered trademark SIPROTEC designates the product family of protection devices and fault recorders.

Slave device

A slave may only exchange data with a master after its has been requested to do so by this master. SIPROTEC devices work as slaves. A master computer controls a slave computer. A master computer can also control a peripheral device.

SLD

Single-line diagram

SLE

Single-Line Editor

SNMP

Simple Network Management Protocol

SNTP

Simple Network Time Protocol

SOE

Sequence of Events

SP

See Single-Point Indication

SPC

IEC 61850 data type: Single Point Control

SPS

IEC 61850 data type: Single point status

SSD

System Specification Description

ST

Structured Text file

Station Description

A station description is an IEC 61850-compliant file for data exchange between the system configurator and the IED configurator. The station description contains information on the network structure of a substation. The station description contains for example, information on the assignment of the devices to the primary equipment, as well as on the station-internal communication.

Structured Text file

You can import function charts (CFC) from DIGSI 4 in ST format. First, however, export your function charts from DIGSI 4.83 or higher.

Substation Configuration Description Language

A description language standardized in IEC 61850. SCL is based on XML. This description language allows all information relevant to an IEC 61850 substation to be documented consistently. This format is therefore suitable for exchanging IEC 61850-specific data between different applications, even if these come from different manufacturers. The described import checks are basically done for all SCL formats, not only for SCD imports.

System Exchange Description

Files in SED format can be used to exchange interface information between DIGSI 5 projects and thus between substations. To do this, the project extracts the data for the other projects from the file during import and writes its own data in the same file during export. The contents of an SED file are formulated in SCL.

System Specification Description

Files in SSD format contain the complete specification of a station automation system, including a single-line configuration of the station. The assignment of logical nodes from IEC 61850 to primary equipment can also be described in SSD files. This allows device requirements to be defined in the SSD file so that the devices can be used in the substation. The contents of an SED file are formulated in SCL.

TAI

Temps Atomique International - International Atomic Time

TC

Tap-position command - see Transformer Tap Position Command

TCP

Transmission Control Protocol

TEA-X

You can archive the data from individual SIPROTEC 5 devices or whole project in TEA-X format. This format is also suitable for data exchange between different applications, such as DIGSI 5 and Engineering Base (EB). The TEA-X format is based on XML.

Telephone book

Participant addresses for the modem connection are saved in this object type.

Time stamp

A time stamp is a value in a defined format. The time stamp assigns a time point to an event, for example, in a log file. Time stamps ensure that events can be found again.

Topological view

The Topological View is oriented to the objects of a system (for example, switch gear) and their relation to one another. The Topological View describes the structured layout of the system in hierarchical form. The Topological View does not assign the objects to the devices.

Transmission Control Protocol

The Transmission Control Protocol (TCP) is a transmission protocol for transport services in the Internet. TCP is based on IP and ensures connection of the participants during the data transmission. TCP ensures the correctness of the data and the correct sequence of the data packages.

Transparent Clock

The Precision Time Protocol knows different types of clocks: an ordinary clock (abbreviation: OC), a boundary clock (BC), and a transparent clock (TC). The transparent clock was added to the specification in 2008 and

improves the time-information transmission within a network by receiving PTP messages and transmitting them after modification (correction).

Tree view

The left area of the project window visualizes the names and symbols of all containers of a project in the form of a hierarchical tree structure. This area is referred to as a tree view.

Tunneling

Technology for connecting two networks via a third network, whereby the through traffic is completely isolated from the traffic of the third network.

UDP

User Datagram Protocol

Unbuffered Report Control Block

Unbuffered Report Control Block (URCB) is a form of report controlling. Internal events trigger the immediate sending of reports based on best effort. If no association exists or if the transport data flow is not fast enough, events can be lost.

URCB

Unbuffered Report Control Block

USART

Universal Synchronous/Asynchronous Receiver/Transmitter

User Datagram Protocol (UDP)

UDP is a protocol. The protocol is based on IP as TCP. In contrast to this, however, UDP works without a connection and does not have any safety mechanisms. The advantage of UDP in comparison to IP is the higher transmission rate.

UTC

Universal Time Coordinated

Vendor ID

Manufacturer-specific part of the device identification for PROFINET.

Virtual Device

A VD (virtual device) comprises all communication objects, as well as their properties and states, which a communication user can utilize in the form of services. A VD can be a physical device, a module of a device or a software module.

WYE

Phase to ground related measurements of a 3 phase system

ВЯРНО С ОРИГИНАЛА

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SIEMENS

SIPROTEC 5

Transformer Differential Protection

7UT82, 7UT85, 7UT86, 7UT87

V7.30 and higher

Manual

C53000-G5040-C016-7

NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

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Edition: 06.2016
Version of the product described: V7.30 and higher

Preface

Purpose of the Manual

This manual describes the functions for transformer protection.

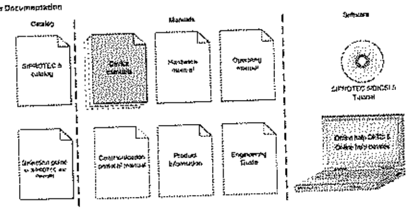
Target Audience

Protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the SIPROTEC 5 device family.

Further Documentation



- Device manuals
  Each Device manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.
- Hardware manual
  The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.
- Operating manual
  The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.

- Communication protocol manual
  The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher-level network control centers.
- Product information
  The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.
- Engineering Guide
  The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a planned configuration to a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.
- DIGSI 5 online help
  The DIGSI 5 online help contains a help package for DIGSI 5 and CFC.
  The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.
- SIPROTEC 5/DIGSI 5 Tutorial
  The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.
- SIPROTEC 5 catalog
  The SIPROTEC 5 catalog describes the system features and the devices of SIPROTEC 5.
- Selection guide for SIPROTEC and Reyrolle
  The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

Indication of Conformity

CE

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive) and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens AG.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Other Standards

IEEE Std C 37.90

The technical data of the product is approved in accordance with UL.

For more information about the UL database, see ul.com

Select Online Certifications Directory and enter E194016 as UL File Number.

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IND. CONT. EQ.
69CA

Additional Support

For questions about the system, please contact your Siemens sales partner.

Support

Our Customer Support Center provides a 24-hour service.

Phone:	+49 (180) 524-7000
Fax:	+49 (180) 524-2471
E-Mail:	support.energy@siemens.com

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG
Siemens Power Academy TD

Humboldtstraße 59
90459 Nürnberg
Germany

Phone:	+49 (911) 433-7415
Fax:	+49 (911) 433-7929
E-Mail:	poweracademy@siemens.com
Internet:	www.siemens.com/poweracademy

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:

DANGER

DANGER means that death or severe injury will result if the measures specified are not taken.

- Comply with all instructions, in order to avoid death or severe injuries.

WARNING

WARNING means that death or severe injury may result if the measures specified are not taken.

- Comply with all instructions, in order to avoid death or severe injuries.

CAUTION

CAUTION means that medium-severe or slight injuries can occur if the specified measures are not taken.

- Comply with all instructions, in order to avoid moderate or minor injuries.

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NOTICE

NOTICE means that property damage can result if the measures specified are not taken.

- Comply with all instructions, in order to avoid property damage.

NOTE

Important information about the product, product handling or a certain section of the documentation which must be given particular attention.

Qualified Electrical Engineering Personnel

Only qualified electrical engineering personnel may commission and operate the equipment (module, device) described in this document. Qualified electrical engineering personnel in the sense of this manual are people who can demonstrate technical qualifications as electrical technicians. These persons may commission, isolate, ground and label devices, systems and circuits according to the standards of safety engineering.

Proper Use

The equipment (device, module) may be used only for such applications as set out in the catalogs and the technical description, and only in combination with third-party equipment recommended and approved by Siemens.

Problem-free and safe operation of the product depends on the following:

- Proper transport
- Proper storage, setup and installation
- Proper operation and maintenance

When electrical equipment is operated, hazardous voltages are inevitably present in certain parts. If proper action is not taken, death, severe injury or property damage can result:

- The equipment must be grounded at the grounding terminal before any connections are made.
- All circuit components connected to the power supply may be subject to dangerous voltage.
- Hazardous voltages may be present in equipment even after the supply voltage has been disconnected (capacitors can still be charged).
- Operation of equipment with exposed current-transformer circuits is prohibited. Before disconnecting the equipment, ensure that the current transformer circuits are short-circuited.
- The limiting values stated in the document must not be exceeded. This must also be considered during testing and commissioning.

Open Source Software

The product contains, among other things, Open Source Software developed by third parties. The Open Source Software used in this product and the license agreements concerning this software can be found in the Readme_OSS. These Open Source Software files are protected by copyright. Your compliance with those license conditions will entitle you to use the Open Source Software as foreseen in the relevant license. In the event of conflicts between Siemens license conditions and the Open Source Software license conditions, the Open Source Software conditions shall prevail with respect to the Open Source Software portions of the software. The Open Source Software is licensed royalty-free. Insofar as the applicable Open Source Software License Conditions provide for it you can order the source code of the Open Source Software from your Siemens sales contact - against payment of the shipping and handling charges - for a period of at least 3 years since purchase of the Product. We are liable for the Product including the Open Source Software contained in it pursuant to the license conditions applicable to the Product. Any liability for the Open Source Software beyond the program flow intended for the Product is explicitly excluded. Furthermore any liability for defects resulting from modifications to the Open Source Software by you or third parties is excluded. We do not provide any technical support for the Product if it has been modified.

When using DIGSI 5 in online mode, you are provided with the option to go to the main menu **Show Open source information** and read and display the Readme_OSS file containing the original license text and copyright information.

To do this, the following steps are necessary:

- Switch to online mode.
- Select the device.
- Select online in the menu bar.
- Click **Show Open source information**.

NOTE

To read the Readme_OSS file, a PDF viewer must be installed on the computer.
In order to operate SIPROTEC 5 devices, a valid DIGSI 5 license is required.

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1 Introduction

1.1 General

The digital multifunctional protection and bay controllers of the SIPROTEC 5 device series are equipped with a powerful microprocessor. As a result, all tasks, from acquiring measurands to entering commands in the circuit breaker, are processed digitally.

Analog Inputs

The measuring inputs transform the currents and voltages sent by the instrument transformers and adapt them to the internal processing level of the device. A SIPROTEC 5 device has a current transformer and, depending on the device type, a voltage transformer. The current inputs are therefore intended for the detection of phase currents and ground current. The ground current can be detected sensitively using a core balance current transformer. In addition, phase currents can be detected very sensitively for a particularly precise measurement. The voltage inputs detect the measuring voltage of device functions requiring current and voltage measured values.

The analog values are digitized in the internal microcomputer for data processing.

Microcomputer System

All device functions are processed in the microcomputer system.

This includes, for example:

- Filtering and preparation of the measurands
- Constant monitoring of the measurands
- Monitoring of the pickup conditions for the individual protection functions
- Querying of limiting values and time-outs
- Controlling of signals for the logic functions
- Decision about the trip and close commands
- Storage of indications, fault data, and fault values for fault analysis
- Administration of the operating system and its functions, such as data storage, real-time clock, communication, interfaces, etc.
- External distribution of information

Binary Inputs and Outputs

Using the binary inputs and outputs, the device receives information from the system or from other devices (such as locking commands). The most important outputs include the commands to the switching devices and the indications for remote signaling of important events and states.

Front Elements

For devices with an integrated or offset operation panel, LEDs and an LC display on the front provide information on the device function and report events, states, and measured values. In conjunction with the LC display, the integrated keypad enables on-site operation of the device. All device information such as setting parameters, operating and fault indications or measured values can be displayed, and setting parameters changed. In addition, system equipment can be controlled via the user interface of the device.

Serial Interfaces

The serial interface in the front cover enables communication with a personal computer when using the DIGSI operating program. As a result, the operation of all device functions is possible. Additional interfaces on the back are used to realize various communication protocols.

Power Supply

The individual functional units of the device are powered by an internal power supply. Brief interruptions in the supply voltage, which can occur during short circuits in the system auxiliary voltage supply are generally bridged by capacitor storage (see also the Technical Data).

1.2 Properties of SIPROTEC 5

The SIPROTEC 5 devices at the bay level are compact and can be installed directly in medium and high-voltage switchgear. They are characterized by comprehensive integration of protection and control functions.

General Properties

- Powerful microprocessor
- Fully digital measured-value processing and control, from sampling and digitizing of measurands to closing and tripping decisions for the circuit breaker
- Complete galvanic and interference-free isolation of the internal processing switches from the system measuring, control, and supply circuits through instrument transformers, binary input and output modules, and DC and AC voltage converters
- Easy operation using an integrated operator and display panel, or using a connected personal computer with user interface
- Continuous display of measured and metered values at the front
- Storage of min/max measured values (slave pointer function) and storage of long-term average values
- Storage of fault indications for system incidents (faults in system) with real-time assignment and instantaneous values for fault recording
- Continuous monitoring of the measurands as well as the device hardware and software
- Communication with central control and storage devices possible via the device interface
- Battery-buffered, synchronizable clock

Modular Concept

The SIPROTEC 5 modular concept ensures the consistency and integrity of all functionalities across the entire device series. Significant features here include:

- Modular system design in hardware, software, and communication
- Functional integration of various applications, such as protection, control, and fault recorder
- The same expansion and communication modules for all devices in the family
- Innovative terminal technology with easy assembly and interchangeability and the highest possible degree of safety
- The same functions can be configured individually across the entire family of devices
- Ability to upgrade with innovations possible at all times through libraries
- Open, scalable architecture for IT integration and new functions
- Multi-layered security mechanisms in all links of the security chain
- Self-monitoring routines for reliable localization and indication of device faults
- Automatic logging of access attempts and safety-critical operations on the devices and systems

Redundant Communication

SIPROTEC 5 devices maintain complete communication redundancy:

- Multiple redundant communication interfaces
- Redundant and independent protocols to control centers possible (such as IEC 60870-5-103 and IEC 61850, either single or redundant)
- Redundant time synchronization (such as IRIG-B, SNTP, or IEEE 1588)

1.3 Overview of Transformer Protection Devices

The protected object can be a power transformer in multi-winding design as well as an auto transformer. The main protection functions supplement the transformer differential protection by the restricted ground-fault protection. In addition more supplemental protection functions can be activated.

The protection device classification is oriented to the basic design of the protected object. The simplest design is a two-winding transformer with different vector groups. The design can also be the simplest form of the auto transformer. After that comes the three-winding transformer with different vector group design. The design can also be an auto transformer with stabilizing winding. The last groups are multi-winding transformers, which are often found with converter applications (for example high-voltage direct-current transmission).

An important differentiating characteristic of the devices is the ability to process the number of windings (in the following called transformer sides) and the number of measuring points. For the transformer sides, the 7UT8x offers greater flexibility. In this way, you can expand the 7UT85 (two-winding transformer) to up to 3 transformer sides and the 7UT86 (three-winding transformer) to up to 4 transformer sides only with function points, if necessary. This allows greater flexibility for plant expansions or for spare parts stocking.

The following table gives you a rough overview of the 4 classes of the transformer differential protection device.

Table 1-1 Classification of the Devices

7	UT		Essential Differentiating Characteristics
7	UT	82	Two-winding transformer (2 sides and maximum 2 measuring points)
7	UT	85	Two-winding transformer (3 sides of which 2 are open and a maximum of 5 measuring points)
7	UT	86	Three-winding transformer (4 sides of which 3 are open and a maximum of 6 measuring points)
7	UT	87	Multi-winding transformer (5 sides and maximum 9 measuring points)

With 7UT87 there is a special feature. Due to the maximum number of 5 sides, the simultaneous protection of 2 transformers (for example from 2 two-winding transformers) is possible through one device. More information on possibilities for use can be found in the device catalog or the application templates in Chapter 4 Applications.

Typical properties of the 4 device types are presented in the following tables:

Table 1-2 Properties – 7UT82

Brief description	Differential protection for two-winding transformers for all voltage levels
Main protection function	1 differential protection function (standard transformer) with additional stabilization; up to 2 restricted ground-fault protection functions
Usable measuring points	2 one-phase current measuring points 2 three-phase current measuring points
Inputs and outputs	One predefined standard variant with 8 current transformers, 7 binary inputs, 6 binary outputs
Width of housing	1/3 x 19 inches

Table 1-3 Properties – 7UT85

Brief description	Differential protection for two-winding transformers for all voltage levels
Main protection function	1 differential protection function (standard or auto transformer) with additional stabilization; up to 2 restricted ground-fault protection functions
Usable measuring points	5 three-phase current measuring points 3 one-phase current measuring points 3 three-phase voltage measuring points 2 one-phase voltage measuring points
Inputs and outputs Hardware flexibility	2 predefined standard variants with 8 current transformers, 7 to 19 binary inputs, 7 to 23 binary outputs Flexible adaptable and expandable I/O quantity structure of the modular SIPROTEC 5 module
Width of housing	1/3 × 19 inches to 1/1 × 19 inches

Table 1-4 Properties – 7UT86

Brief description	Differential protection for three-winding transformers for all voltage levels
Main protection function	1 differential protection function (standard) with additional stabilization; up to 3 restricted ground-fault protection functions For auto transformer applications 2 differential protection functions can be processed in an auto transformer function group.
Usable measuring points	6 three-phase current measuring points 4 one-phase current measuring points 4 three-phase voltage measuring points 3 one-phase voltage measuring points
Inputs and outputs Hardware flexibility	4 predefined standard variants with 12 current transformers, 4 voltage transformers, 11 to 23 binary inputs, 19 to 34 binary outputs Flexible adaptable and expandable I/O quantity structure of the modular SIPROTEC 5 module
Width of housing	1/2 × 19 inches to 1/1 × 19 inches

Table 1-5 Properties – 7UT87

Brief description	Differential protection for multi-winding transformers for all voltage levels
Main protection function	Up to 2 differential protection functions with additional stabilization (in different transformer function groups); up to 5 restricted ground-fault protection functions For auto transformer applications 2 differential protection functions can be processed in an auto transformer function group.
Usable measuring points	9 three-phase current measuring points 5 one-phase current measuring points 5 three-phase voltage measuring points 5 one-phase voltage measuring points
Inputs and outputs Hardware flexibility	2 predefined standard variants with 20 current transformers, 4 voltage transformers, 15 to 27 binary inputs, 22 to 38 binary outputs Flexible adaptable and expandable I/O quantity structure of the modular SIPROTEC 5 module
Width of housing	2/3 × 19 inches to 1/1 × 19 inches

The important functional properties of the devices are:

- Transformer protection for two-, three- and multi-winding transformers with versatile, additional protection functions
- Universal usability of the permissible measuring points
- Applicable from average up to extra-high voltage
- Protection from standard power transformers and auto transformers
- Typical properties of a transformer differential protection, such as flexible adaptation to the transformer vector group, command of closing and overexcitation processes, reliable behavior in current-transformer saturation with different degrees of saturation
- Increased sensitivity with near-neutral-point ground faults through a separate restricted ground-fault protection

- Voltage controller for the control and regulation of the on-load tap changer
- Additional current and voltage inputs can be supplements for standard protection functions, such as overcurrent, voltage frequency, etc.
- In the standard design 2 communication modules are pluggable, as well as different protocols are usable (IEC 61850, IEC 60870-5-103, DNP3 (serial+IP), Modbus (IED View)
- Performance automation with CFC (Continuous Function Chart)
- Secure serial protection data communication, also over great distances and all available physical media (optical fibers, two-wire connections and communication networks)
- Measurement of all relevant operating variables
- Powerful fault recording
- Consistent monitoring concept
- Auxiliary functions for simple tests and commissioning

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2 Basic Structure of the Function

2.1 Function Embedding in the Device

General

SIPROTEC 5 devices offer great flexibility in the handling of functions. Functions can be individually loaded into the device. Additionally, it is possible to copy functions within a device or between devices. The necessary integration of functions in the device is illustrated by the following example.

NOTE

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

EXAMPLE

A 1 1/2 circuit-breaker layout of the 7SA86 distance protection device serves as an example. The following protection functions are required for implementation (simplified and reduced):

- Distance protection (21)
- Overcurrent protection, phases (51)
- Circuit-breaker failure protection (50BF), for circuit breakers 1 and 2
- Basic functionality (handling of tripping, etc.)

Several predefined function packages that are tailored to specific applications exist for each device family. A predefined functional scope is called an application template. The existing application templates are offered for selection automatically when you create a new device in DIGSI 5.

EXAMPLE

When creating the device in DIGSI 5, you must select the appropriate application template. In the example, select the application template DIS overhead line, grounded systems, 1 1/2 circuit-breaker layout. This application template covers the required functional scope. Selecting this application template determines the preconfigured functional scope. This can be changed as necessary (see chapter 2.2 Adjustment of Application Templates/Functional Scope).

Function Groups (FG)

Functions are arranged in function groups. This simplifies handling of functions (adding and copying). The function groups are assigned to primary objects, such as a line, transformer, or circuit breaker.

The function groups bundle functions with regard to the following basic tasks:

- Assignment of functions to current and/or voltage transformers (assignment of functions to the measuring points and thus to the protected object)
- Exchange of information between function groups

When a function is copied into a function group, it automatically works with the measuring points assigned to the function group. Their output signals are also automatically included in the configured interfaces of the function group.

The number and type of function groups differ in the respective application templates, depending on the type of the device and application. You can add, copy, or even delete function groups for a specific application. You can also adapt the functional scope within a function group according to the use case. You can find detailed information on this in the DIGSI 5 Online help.

EXAMPLE

The selected application template DIS overhead line, grounded systems, 1 1/2 circuit-breaker layout comprises 3 function groups:

- Protection function group Line 1
- Circuit-breaker function group QA 1
- Circuit-breaker function group QA 2

The following figure shows the embedding of functions via function groups.

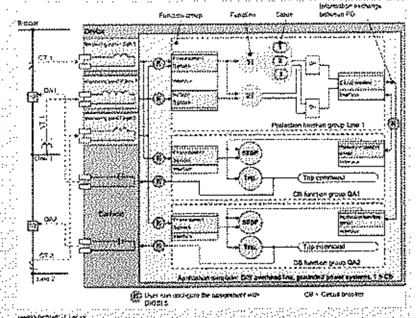

Figure 2-1 Embedding the Functions via Function Groups

Depending on the type of device, there are different types of function groups:

- Protection function groups
- Circuit-breaker function groups

Protection function groups bundle functions that are assigned to one protected object – for example, to the line. Depending on the device type and nature of the protected object, there are different types of protection function groups (line, voltage/current 3-phase, transformer, motor, generator, etc.).

Circuit-breaker function groups bundle functions assigned to the local switches – for example, circuit breakers and disconnectors (such as processing of tripping, circuit-breaker failure protection, ...).

The number and type of function groups differ in the respective application templates, depending on the type of the device and application. You can add, copy, or even delete function groups for a specific application. You can also adapt the functional scope within a function group according to the use case. Detailed information on this can be found in the DIGSI 5 Online help.

Interface Between Function Group and Measuring Point

The function groups receive the measurands of the current and voltage transformers from measuring points. For this, the function groups are connected to one or more measuring points.

The number of measuring points and the assignment of function groups to the measuring points are preset by the selected application template in accordance with the specific application. Therefore, this specifies which measuring point(s) and the corresponding measurands have to be used by which function within the function group.

EXAMPLE

The measuring points are assigned to the function groups in the application template in Figure 2-1 as follows:

- The protection function group Line is assigned to the measuring points I-3ph 1, I-3ph 2 and V-3ph 1. The function group therefore receives the measured values from current transformers 1 and 2 and from voltage transformer 1. The currents of measuring points I-3ph 1 and I-3ph 2 are added geometrically for line-related processing.
- The circuit-breaker function group QA1 is assigned to the measuring point I-3ph 1 and receives the measured values from current transformer 1.
- The circuit-breaker function group QA2 is assigned to the measuring point I-3ph 2 and receives the measured values from current transformer 2.

The user can change the assignment as needed, that is, function groups can be assigned to any available measuring points of the device.

To check or change the assignment of measuring points to the function groups, double-click Function-group connections in the DIGSI 5 project tree.

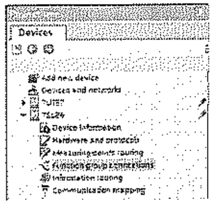

Figure 2-2 Project Tree in DIGSI 5 (Detail)

The window for routing of the measuring points opens in the working area (see the following Figure, does not correspond to the example).

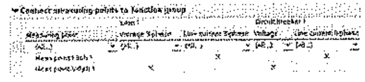

Figure 2-3 Connecting Measuring Points and Function Groups

Interface Between Protection and Circuit-Breaker Function Groups

The protection function group(s) is/are connected to one or several circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are started by the protection functions of the protection FG.
- Starting the Circuit-breaker failure protection function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the Automatic reclosing function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected Protection function group

Besides the general assignment of the protection function group(s) to the circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Further information on this is included later in the section. Figure 2-6 shows how to reach the detail configuration. Figure 2-7 shows the possible assignments in detail.

These definitions are also set appropriately for the specific application by the selected application template.

The user can change this linkage as needed, that is, protection function groups can be freely assigned to any circuit-breaker function groups.

To check or change the allocation of the protection function groups to the circuit-breaker function groups, double-click Function group connections in the DIGSI 5 project tree → Name of device (see following figure).

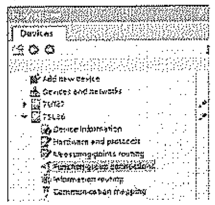

Figure 2-4 Project Tree in DIGSI 5 (Detail)

The window for general routing of the function groups opens in the working area (see following figure).

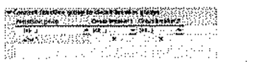

Figure 2-5 Connection of Protection Function Group with Circuit-Breaker Function Groups

Besides the general assignment of the protection function group(s) to the circuit-breaker function groups, you can also configure the interface for specific functionalities in detail. Proceed as follows:

- Open the SIPROTEC 5 device folder in the DIGSI 5 project tree.
- Open the function settings folder in the DIGSI 5 project tree.
- Open the respective protection function group in the DIGSI 5 project tree, for example, Line 1 (see the following figure)

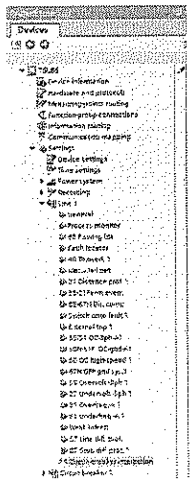

Figure 2-6 Project Tree in DIGSI 5 (Detail)

- Double-click Circuit-breaker interaction (see Figure 2-6)
- The window for detailed configuration of the interface between the protection function group and the circuit-breaker function group(s) opens in the working area
- In this view, configure the interface via the context menu (right mouse button), see Figure 2-7

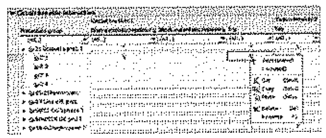

Figure 2-7 Detail Configuration of the Interface Between the Protection Function Group and the Circuit-Breaker Function Group(s)

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions block the automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

Functions (FN), Tripping Stages/Function Blocks (FB)

As already illustrated in Figure 2-1, functions are assigned to the protected objects or other primary objects via function groups.

Functions can be further subdivided. For example, protection functions often consist of multiple protection stages (for example, the Overcurrent protection function). Other functions can contain one or more function blocks.

Each stage, each function block, and each function (without stages/function blocks) can be individually switched into specific operating modes (for example, switch on/off). This is termed function control and is explained in chapter 2.5 Function Control.

To adjust the functionality to the specific application, functions, tripping stages, and function blocks can be added, copied, and deleted (see chapter 2.2 Adjustment of Application Templates/Functional Scope).

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2.2 Adjustment of Application Templates/Functional Scope

Application Templates

The application template defines the preconfigured functional scope of the device for a specific use case. A certain number of application templates is predefined for each device type. DIGSI 5 automatically offers the application templates for selection when a new device is installed. The available application templates with the respective functional scope are described in more detail in 4 Applications.

The selection of the application template first predefines which function groups and functions are present in the device (see also Figure 2-1 in chapter 2.1 Function Embedding in the Device).

You can adjust the functional scope to your specific application.

Adjusting the Functional Scope

Adjust the functional scope based on the selected application template. You can add, copy or delete functions, tripping stages, function blocks, or complete function groups.

In the DIGSI 5 project tree, this can be done via the following Editors:

- Single-line configuration
- Information routing
- Function settings

Siemens recommends the Single-line configuration Editor to adjust the functional scope.

Complete missing functionalities from the Global DIGSI 5 Library. Then, the default settings of the added functionality are active. You can copy within a device and between devices as well. Settings and routings are also copied when you copy functionalities.

NOTE

If you delete a parameterized function group, function, or level from the device, all settings and routings will be lost. The function group, function, or tripping stage can be added again, but then the default settings are active.

In most cases, the adjustment of the functional scope consists of adding and deleting functions, tripping stages, and function blocks. As previously described, the functions, tripping stages, and function blocks automatically connect themselves to the measuring points assigned to the function group.

In few cases, it may be necessary to add a protection or circuit-breaker function group. These newly added function groups do not contain (protection) functions. You must individually load the (protection) functions for your specific application. You must also connect the protection or circuit-breaker function group to one or more measuring points (see chapter 2.1 Function Embedding in the Device). You must connect newly added protection function groups to a circuit-breaker function group (see chapter 2.1 Function Embedding in the Device).

Functions, tripping stages, function blocks, and function groups can be added up to a certain maximum number. The maximum number can be found in the respective function and function-group descriptions.

Function Points

Function points (FP) are assigned to specific functions, but not to other functions. Further information can be found in the description of application templates, in the chapter 4 Applications.

The device is supplied with the acquired function-point credit. Functions with function points can be loaded into the device only within the available function-point credit. The functional scope cannot be loaded into the device if the required number of points of the functional scope is higher than the function-point credit. You must either delete functions or upgrade the function-point credit of the device.

No function points are required to add additional stages in functions.

Extending the Function-Point Credit

You can reorder function points if the function-point credit for the device is not enough.

Proceed as follows:

- Determine the function-point requirement of certain functions, for example, with DIGSI 5 or the SIPROTEC 5 Configurator.
- Order the additional function points from your local distributor or at http://www.energy.siemens.com.
- Siemens will provide you with a signed license file for your device, either via e-mail or for downloading.
- Use DIGSI 5 to load the signed license file into your device. The procedure is described in the Online Help of DIGSI 5.

2.3 Function Control

Function control is used for:

- Functions that do not contain stages or function blocks
- Stages within functions
- Function blocks within functions

NOTE

Simplifying Functions and Function control will be discussed in the following. The description also applies to tripping stage control and function block control.

Functions can be switched to different operating modes. You use the parameter **Mode** to define whether you want a function to run (On) or not (Off). In addition, you can temporarily block a function or switch it into test mode for the purpose of commissioning (parameter Mode = Test).

The function shows the current status – such as an Alarm via the Health signal.

The following explains the different operating modes and mechanisms and how you set the functions into these modes. The function control is shown in Figure 2-8. It is standardized for all functions. Therefore, this control is not discussed further in the individual function descriptions.

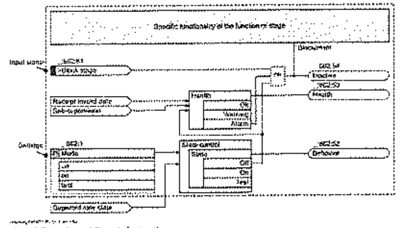

Figure 2-8 General Control of a Function

State Control

You can control the state of a function via the parameter **Mode** and the input **Superordinate state**.

You set the specified operating state of the function via the parameter **Mode**. The function mode can be set to On, Off, and Test. The operating principle is described in Table 2-2. You can set the parameter **Mode** via:

- DIGSI 5
- On-site operation at the device
- Certain systems control protocols (IEC 61850, IEC 60870-5-103)

The possibility to adjust the **superordinate state** is limited. For test purposes, the complete device can set into test mode.

The state of the function resulting from the parameter **Mode** and the superordinate state is shown in the following table.

Table 2-1 Resulting State of the Function (from Linkage of Parameter Mode and Superordinate State)

Inputs		Function State
Mode Parameter (of the function)	Superordinate State	
Off	(any)	Off
(any)	Off	Off
On	On	On
On	Test	Test
Test	On	Test
Test	Test	Test

The following table shows the possible function states:

Table 2-2 Possible Function States

Function State	Explanation
On	The function is activated and operating as defined. The prerequisite is that the health of the function is OK.
Off	The function is turned off. It does not create any information. The health of a disabled function always has the value OK.

<table>
<tr><th>Function State</th><th colspan="2">Explanation</th></tr>
<tr><td rowspan="7">Test</td><td colspan="2">The function is set to test mode. This state supports the commissioning. All outgoing information from the function (indications and, if present, measured values) is provided with a test bit. This test bit significantly influences the further processing of the information, depending on the target.
For instance, among other things, it is possible to implement the functionality Blocking of the command relay known from SIPROTEC 4.</td></tr>
<tr><td>Target of the Information</td><td>Processing</td></tr>
<tr><td>Log</td><td>The indications are provided with the identification Test in the log.</td></tr>
<tr><td>Contact</td><td>An indication routed to contact is not triggering the contact.</td></tr>
<tr><td>Light-emitting diode (LED)</td><td>An indication routed to the LED triggers the LED (normal processing)</td></tr>
<tr><td>CFC</td><td>Here, the behavior depends on the state of the CFC chart.
• CFC chart itself is not in test state:
The CFC chart is not triggered by a status change of information with a set test bit. The initial state of the information (state before test bit was set) is processed during execution of the CFC chart.
• CFC chart itself is in test state:
The CFC chart continues to process the information (indication or measured value) normally. The CFC outgoing information is provided with a test bit. The definitions in this table apply to its continued processing.
A CFC chart can be set to the test state only by switching the entire device to test mode.</td></tr>
<tr><td>Protocol</td><td>Indication and measured value are transmitted with set test bit, provided that the protocol supports this functionality.
If an object is transmitted as a GOOSE message, the test bit is set spontaneously and the GOOSE message is transmitted immediately. The receiver of the GOOSE message is automatically notified of transmitter test mode.
If an object is transmitted via the protection interface, the test bit is not transmitted. The Test state must also be transmitted as information for the state to be taken into account in the application on the receiver end. You must route the Test signal in the DIGSI 5 project tree → Device → Communication routing.
The test mode of the differential protection will be dealt with separately in the application.</td></tr>
</table>

Health

Health signals if a selected function can perform its designated functionality. If so, the health is OK. In case the functionality is only possible in a limited way or not at all, due to state or problems within the device, the health will signal Warning (limited functionality) or Alarm (no functionality).

Internal self-supervision can cause the functions to assume the health Alarm (see chapter 8 Supervision Functions). If a function assumes the health state Alarm, it is no longer active (indication not active is generated).

Only a few functions can signal the health state Warning. The health state Warning results from function-specific supervision and – where it occurs – it is explained in the function description. If a function assumes the Warning status, it will remain active, that is, the function can continue to work in a conditional manner and trip in the case of a protection function.

Not Active

The indication Not active signals that a function is currently not working. The indication Not active is active in the following cases:

- Function is switched off
- The function is in the health state Alarm
- Function is blocked by an input signal (see Figure 2-8)

Blocking of the Operate Indication, No Fault Recording at Pickup

You use the parameter **Blk. Op. Ind. & Fault Rec.** to define whether a function works as a protection or supervision function. Further, you use this to determine the type and scope of the logging (see following table)

Parameter Value	Description
No	The function works as a protection function. It generates an operate indication and starts fault recording with pickup. During fault recording, a fault is created and logged as a fault record in the fault log.
Yes	The function works as a supervision function. The logic runs normally, but without creating the operate indication. The time-out indication is still generated and can be processed further if necessary. No fault recording starts with pickup.

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2.4 Text Structure and Reference Number for Settings and Indications

Each parameter and each indication has a unique reference number within every SIPROTEC 5 device. The reference number gives you a clear reference, for example, between an indication entry in the buffer of the device and the corresponding description in the manual. You can find the reference numbers in this document, for example, in the application and setting notes, in the logic diagrams, and in the parameter and information lists.

In order to form explicit texts and reference numbers, each function group, function, function block/stage, and indication or parameter has a text and a number. This means that structured overall texts and numbers are created.

The structure of the texts and the reference numbers follow the hierarchy already shown in Figure 2-1.

- Function group:Function:Stage/Function Block:Indication
- Function group:Function:Stage/Function Block:Parameter

The colon serves as a structure element to separate the hierarchy levels. Depending on the functionality, not all hierarchy levels are always available. Function Group and Stage/Function block are optional. Since the function groups, functions as well as tripping stages/function blocks of the same type can be created multiple times, a so-called instance number is added to these elements.

EXAMPLE

The structure of the text and reference number is shown in the protection function group Line as an example of the parameter Threshold value and the indication Op delay of the 2nd definite time-overcurrent protection stage of the function Overcurrent protection, phases (see Figure 2-9). Only one function and one function group exist in the device. The representation of the stage is simplified.

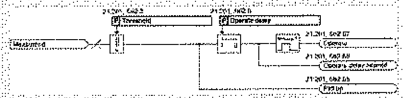

Figure 2-9 Stage of the Overcurrent Protection Function, Phases (without Representation of Stage Control)

The following table shows the texts and numbers of the hierarchy elements concerned:

	Name	Number of the Type	Instance Number
Protection function group	Line	2	1
Function	Overcurrent 3ph	20	1
Stage	Definite time-overcurrent protection	66	2
Settings	Threshold value	3	-
Indication	Pickup	55	-

Die Instanznummern ergeben sich wie folgt:

- Function group: Line 1
  1 instance, because only one Line function group exists in the device
- Function Overcurrent 3ph 1
  1 instance, because only one Overcurrent 3ph function exists in the Line function group

- Stage: Definite time-overcurrent protection 2
  2 instances, because 2 definite time-overcurrent protection stages exist in the Overcurrent 3ph function (here the 2nd instance as an example)

This results in the following texts and numbers (including the instance numbers):

Parameter	Number
Line 1:Overcurrent 3-ph 1:Definite time-overcurrent protection 2:Threshold value	21:201:662:3
Indication:	Number
Line 1:Overcurrent 3-ph 1:Definite time-overcurrent protection 2:Pickup	21:201:662:55

The structure is simplified accordingly for parameters and indications with fewer hierarchy levels.

2.5 Information Lists

For the function groups, functions, and function blocks, settings and miscellaneous signals are defined that are shown in the settings and information lists.

The information lists summarize the signals. The data type of the information may differ. Possible data types are ENS, ACD, ACT, SPS and MV, etc.

A type is assigned to the individual data types. The following table shows the possible types:

Type	Meaning
I	Input – input signal
O	Output – output signal
C	Controllable – control signal

EXAMPLE:

The following table shows the types for some data types as examples:

Data Type	Type
ENS	O
ACD	O
ACT	O
SPS	I or O
SPC	C
MV	O

3 System Functions

3.1 Indications

3.1.1 General

During operation, indications deliver information about operational states. These include:

- Measured data
- Power-system data
- Device supervisions
- Device functions
- Function procedures during testing and commissioning of the device

In addition, indications give an overview of important fault events after a failure in the system. All indications are furnished with a time stamp at the time of their occurrence.

Indications are saved in logs inside the device and are available for later analyses. The following number of indications are saved at least in the respective buffer (depending on the scope of the indications):

- Ground-fault log 100 indications
- Fault log 1000 indications
- User-defined log 200 indications
- Operational log 2000 indications

If the maximum capacity of the user-defined log or of the operational is exhausted, the oldest entries disappear before the newest entries. If the maximum capacity of the fault log or of the ground-fault log is reached, the number of the last fault is issued via the signal Fault log is full. During a supply voltage failure, recorded data are secured, held by means of battery buffering or storage in the flash memory. You can read and analyze the log from the device with DIGSI 5. The device display and navigation using keys allow you to read and analyze the logs on site.

Indications can be output spontaneously via the communication interfaces of the device and through external demand via general interrogation. In DIGSI 5 indications can be tracked spontaneously in online operation in a special indication window. Indications can be made accessible to higher-level control systems through mapping on various communication protocols.

> **NOTE**
>
> All indications are assigned to certain device functions. The text of each indication contains the corresponding function designation. You will find explanations of the meaning of indications in the corresponding device functions. However, you can also define indications yourself and group them into your own function blocks. These can be set by binary inputs or CFC logic.

Reading Indications

To read the indications of your SIPROTEC 5 device you can use the on-site operation panel of the device or a PC on which you have installed DIGSI 5. The subsequent section describes the general procedure.

3.1.2 Reading Indications on the On-Site Operation Panel

Procedure

The menus of the logs begin with a header and 2 numbers at the top right corner of the display. The number after the slash signifies the number of indications that are available. The number before the slash indicates how many indications have just been selected or shown. The end of the indication list is closed with the entry ***END***.

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Figure 3-1 On-Site Display of an Indication List (Example: Operational Indications)

Menu Path	Log
Main menu → Indications →	Operational log Fault log Ground-fault log Setting changes User indications 1 User indications 2
Main menu → Test & Diagnosis → Indications →	Security indications Device diagnosis Communication indications

- To reach the desired log from the main menu, use the navigation keys of the on-site operation panel.
- Navigate inside the log using the navigation keys (top/bottom). You will find the most current indication at the top of the list. The selected indication is shown with a dark background.
- Which indications can be shown in the selected log depends on the assignments in the DIGSI 5 information routing matrix or is predefined. You will find information about this in chapter 3.1.5.1 General.
- Every indication contains date, time and its state as additional information.
- In some logs you are given the option of deleting the entire indication list by softkey in the footer of the display. To know more about this, read chapter 3.1.6 Saving and Deleting the Logs.

NOTE

No password entry is necessary to read indications from the device.

3.1.3 Reading Indications from the PC with DIGSI 5

Procedure

Menu Path (Project)	Log
Project → Device → Process data → Log →	Operational log Fault log Ground-fault log Setting changes User indications 1 User indications 2

Menu Path (Project)	Log
Project → Device → Device information → Log →	Security indications Device diagnosis Communication indications

- To read the indications with DIGSI 5 your PC must be connected via the USB user interface of the on-site operation panel or via an Ethernet interface of the device. A direct connection to your PC can be established via the Ethernet interfaces. It is also possible to access all connected SIPROTEC 5 devices via a data network from your DIGSI 5 PC.
- To reach the desired logs of the SIPROTEC 5 device, use the project tree window. If you have not set up the device within a project, you can also attain this via Online access.
- After selecting the desired log, you are shown the last state of the log loaded from the device. To update, it is necessary to synchronize with the log in the device.
- To execute a synchronization with the logs, click the respective button in the headline of the log (see example of ground-fault log in Figure 3-2 a)).

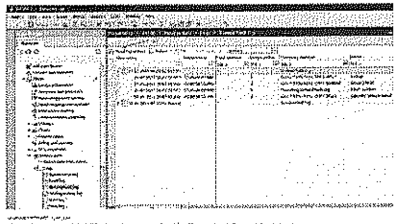

Figure 3-2 DIGSI 5 Display of an Indication List (Example of Ground-Fault Log)

- You will find additional information about the deletion and saving of logs in chapter 3.1.6 Saving and Deleting the Logs.
- To determine a relative time for all other indications, you can reference the display of log entries, if needed, to the real time of a certain entry. The real-time stamps of events remain unaffected.
- For this purpose click the respective button in the headline of the log (see example of ground-fault log in Figure 3-2 b)).

Setting Relative Time Reference

- Which indications in the selected log can be displayed depends on the assignments in the DIGSI 5 information routing matrix or is predefined. You will find information about this in chapter 3.1.5.1 General.

3.1.4 Displaying Indications

Displayed indications in DIGSI 5 and on the on-site operation panel are supplemented with the following information:

Table 3-1 Overview of Additional Information

Indications in	DIGSI 5 Information	Device Display Information
Log for operational indications and log for user-defined indications	Time stamp (date and time), Relative time, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Value
Log for fault indications	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value
Log for ground-fault indications	Time stamp (date and time), Relative time, Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value
Spontaneous indication window (DIGSI 5)	Time stamp (date and time), Error number, Increasing entry number, Value, Indication number, Quality, Cause	Time stamp (date and time), Error number, Value

DIGSI 5: Quality Indication Column

Quality	Meaning
Good	Indication is valid
Invalid	Indication is invalid

DIGSI 5: Additional Information Indication Column

The entries in the column for additional information are in the format Cause/Originator/Additional Cause:

- Cause → What was the reason?
- Originator → Who was the originator?
- Additional cause → Supplementary notes

Cause	Meaning
Data change	Value change in an indication
Data update	Update of notification value
General interrogation	General interrogation

Cause	Meaning
Cyclic	Cyclical general inquiry
Quality change	Change of the notification quality

Initiator	Meaning
Bay	Control local
Substation	Control via the substation
Remote control	Control via the network control center
Field (auto)	Control local via automatic function
Station (auto)	Control via the station via automatic function
Distance (auto)	Control via the network control center via automatic function
Maintenance	Maintenance
Process	Device operation (normal)

Additional Cause	Meaning
Switching authority test failed	Switching authority check failed
Selection failed	Selection failed
Invalid position	Invalid position
Position attained	Position attained
Settings change running	Settings change running
Final position attained	Final position attained
Impermissible mode	Impermissible mode
Blocking through process	Blocking by the process
Interlocked	Interlocked
Synchrocheck failed	Synchrocheck failed
Command already running	Command already running
Not ready	Not ready
1 out of N control failed	1 out of N control failed
Command cancellation	Command cancellation
Monitoring time expired	Monitoring time expired
Cancellation due to trip command	Cancellation due to trip command
Object not selected	Object not selected
No access right	No access right
Final position exceeded	Final position exceeded
Target value not attained	Target value not attained
Loss of connection	Loss of connection
Unknown	Unknown
Blocking through command	Blocking through command
Object already selected	Object already selected
Inconsistent parameter(s)	Inconsistent parameter(s)
Blocked by foreign access	Blocked by foreign access
Select timeout	Select timeout
CB not open	Circuit breaker not open
Communication is interrupted	Communication is interrupted
Topology not stable	Topology not stable
Fault in process	Fault locator in processing
Testing trans diff prot	Testing transformer differential protection
Trigger command active	Trigger command active

Additional Cause	Meaning
Close command active	Close command active
Blocked through protection	Blocked through protection
Fault occurred	Fault occurred
CB not closed	Circuit breaker not closed
CB not ready	Circuit breaker not ready
CB not open	Circuit breaker not open
Close command active	Close command active
CB check running	Circuit breaker check running

3.1.5 Logs

3.1.5.1 General

Indications are saved in logs inside the device and are available for later analyses. Different logs allow categorization of indication logging based on operating states (for example, operational and fault logs) and based on fields of application.

Table 3-2 Log Overview

Log	Logging
Operational log	Operational indications
Fault log	Fault indications
Ground-fault log	Ground-fault indications
Setting-history log	Setting changes
User-defined log	User-defined indication scope
Security log	Access with safety relevance
Device-diagnosis log	Error of the device (software, hardware) and the connection circuits
Communication log	Status of communication interfaces
Motor startup log	Information on the motor startup

Managing Logs

Logs have a ring structure and are automatically managed. If the maximum capacity of a log is exhausted, the oldest entries disappear before the newest entries. If the maximum capacity of the fault or ground-fault log is reached, the number of the last fault is generated via the signal Fault log is full. You can route this signal in the information routing. If indications in the information routing of DIGSI 5 are routed in a log, then they are also saved. During a supply-voltage failure, recorded data are securely held by means of battery buffering or storage in the flash memory. You can read and analyze the log from the device with DIGSI 5. The device display and the navigation allow you to read and evaluate the logs on site using keys.

Configurability of Logs

The indication capacity to be recorded in configurable logs (for example, ground-fault log) is laid down in columns of the information routing (matrix) of DIGSI 5 specifically defined for this purpose.

Procedure

- To reach the information routing of your SIPROTEC 5 device, use the project tree window. Access is only through the project.
  Project → Device → Information routing
- Select the associated routing column in the matrix from:
  Target → Log → Column ground-fault log

- The routing of the selected indication is done via right click. Select one of the options in the list box shown:
  - Routed (X)
  - Unrouted

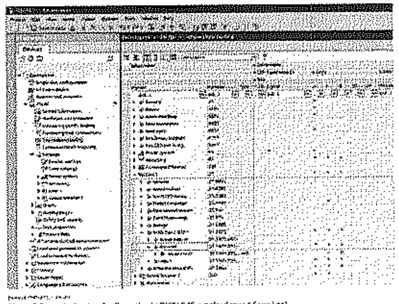

Figure 3-3 Indication Configuration in DIGSI 5 (Example: Ground Fault Log)

For non-configurable logs (for example, setting-history logs) scope and type of logged indications are described separately (see following chapter about logs).

3.1.5.2 Operational Log

Operational indications are information that the device generates during operation. This includes information about:

- State of device functions
- Measured data
- Power-system data

Exceeding or dropping below limiting values is output as an operational indication. Short circuits in the network are indicated as an operational indication Fault with sequential fault number. For detailed information about the recording of system incidents, please refer to the description of the fault log (chapter 3.1.5.3 Fault Log). Up to 2000 indications can be stored in the log.

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Reading from the PC with DIGSI 5

- To reach the operational log of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Process Data → Log → **Operational log**
- The status of the operational log last loaded from the device is shown to you. To update (synchronization with the device) click the button **Read log entries** in the heading of the indication list (Figure 3-4).

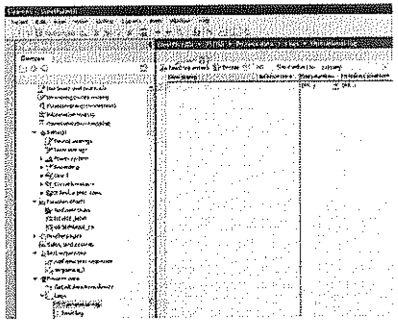

Figure 3-4 Reading the Operational Log with DIGSI 5

Reading on the Device Through the On-Site Operation Panel

- To reach the operational log via the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Operational log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-5
On-Site Display of an Indication List (Example: Operational Indications)

Deletability

The operational log of your SIPROTEC 5 device can be deleted. This is done usually after testing or commissioning the device. To know more about this, read chapter 3.1.6 Saving and Deleting the Logs.

Configurability

The indication scope of the operational log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → Operational log column

Selected application templates and functions from the library bring with them a predefined set of operational indications which you can adjust individually at any time.

3.1.5.3 Fault Log

Fault indications are events which arise during a fault. They are logged in the fault log with real-time stamp and relative time stamp (reference point: fault occurrence). Faults are numbered consecutively in rising order. With fault recording engaged, a corresponding fault record with the same number exists for every fault logged in the fault log. A maximum of 128 fault logs can be stored. A maximum of 2000 indications can be recorded in each fault log.

Fault Definition

In general, a fault is started by the raising pickup of a protection function and ends with the cleared pickup after the trip command.

When using an automatic reclosing function, the complete reclosing cycle (successful or unsuccessful) is preferably integrated into the fault. If evolving faults appear within reclosing cycles, the entire clearing process is logged under one fault number even in multiple pickup cycles. Without automatic reclosing function every pickup is also recorded as its own fault.

User-defined configuration of a fault is also possible.

NOTE

The definition of the fault is done through settings of the fault recording (see Device manual). Events are logged in the fault log even when fault recording is switched off.

Apart from the recording of fault indications in the fault log, spontaneous display of fault indications of the last fault on the device display is also done. You will find details about this in chapter 7.1.4 Spontaneous Fault Display on the On-Site Operation Panel.

Reading from the PC with DIGSI 5

- To reach the fault log of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Process Data → Log → Fault logs

The status of the fault log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Read log entries in the heading of the indication list.

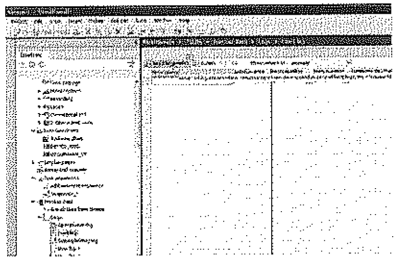

Figure 3-6 Reading the Fault Log with DIGSI 5

Deletability

The fault log of your SIPROTEC 5 device can be deleted. Read about it in chapter 3.1.6 Saving and Deleting the Logs.

Reading on the Device through the On-Site Operation Panel

- To reach the fault log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → Fault logs
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-7
Reading the Fault Log on the On-Site Operation Panel of the Device

Configurability

The indication scope of the fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5:

Target → Log → Fault log column

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

The operational measured values and the measured values of the fundamental components and symmetrical components (see Equipment Manual) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronized with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

3.1.5.4 Ground Fault Log

Ground-fault indications are events which arise during a ground fault. They are logged in the ground-fault log with real-time stamp and relative-time stamp (reference point, ground-fault occurrence). Ground faults are numbered consecutively in rising order. A maximum of 10 ground fault logs are saved and for each ground fault log, it is guaranteed that at least 100 indications are recorded.

The following functions can start the logging of a ground fault with the raising ground-fault indications:

- **Directional sensitive ground-fault protection for deleted and isolated systems (67Ns)**
- **Sensitive ground current protection with I0 (50Ns/51Ns)**
- **Intermittent ground-fault protection**

The logging ends with the going ground fault indication.

Reading from the PC with DIGSI 5

- To reach the ground-fault log of your SIPROTEC 5 device, use the project tree window.
  Project → Device → Process data → Logs → **Ground-fault log**

The status of the device-diagnostic log last loaded from the ground-fault log is shown to you.

- To update (synchronization with the device) click the button Read log entries in the headline of the indication list (Figure 3-8).

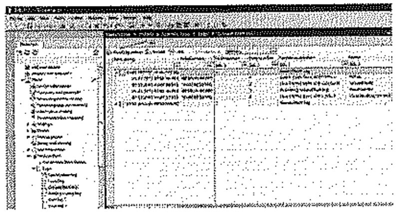

Figure 3-8 Reading the Ground-Fault Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the ground fault log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Ground-fault indication**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-9
Reading the Ground Fault Log on the On-Site Operation Panel of the Device

Deletability

The ground fault log of your SIPROTEC 5 device can be deleted. Read about it in chapter 3.1.6 Saving and Deleting the Logs.

Configurability

The indication scope of the ground fault log is configured in a specifically defined column of the information routing (matrix) of DIGSI 5

Target → Log → Column Ground-fault log

Selected application templates and functions from the library already bring a predefined set of operational indications with them which you can adjust individually at any time.

3.1.5.5 Setting-History Log

All individual setting changes and the downloaded files of entire parameter sets are recorded in the log for setting changes. This enables you to determine setting changes made are associated with events logged (for example, faults). On the other hand, it is possible to prove with fault analyses, for example, that the current status of all settings truly corresponds to their status at the time of the fault. Up to 200 indications can be stored in the setting-history log.

Reading from the PC with DIGSI 5

- To reach the log for setting changes of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → **Setting changes**

The status of the setting-history log last loaded from the device is shown to you.

- To update (synchronization with the device), click the **Read log entries** button in the headline of the indication list (Figure 3-10).

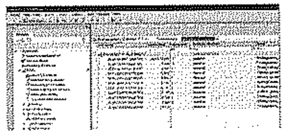

Figure 3-10 Reading the Setting-History Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the setting-history log from the main menu, use the navigation keys of the on-site operation panel.
  Menu → Indications → Setting changes
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-11

ВЯРНО С ОРИГИНАЛА

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Reading the Setting-History Log on the On-Site Operation Panel of the Device

Indication Categories in the Setting History Log

For this log, there is selected information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information.

Table 3-3 Overview of Indication Types

Displayed Information	Explanation
Selection editing+	Selection of settings group to be edited
Reject+	Rejection of all changes successful
PG activation+	PG activation via command successful
PG activation-	PG activation via command failed
Set+	Parameter value was changed
Acceptance+	Acceptance of change successful
Acceptance-	Acceptance of change failed
DCF loaded	DCF loaded into device
SG 1	Settings group 1
SG 2	Settings group 2
SG 3	Settings group 3
SG 4	Settings group 4
SG 5	Settings group 5
SG 6	Settings group 6
SG 7	Settings group 7
SG 8	Settings group 8

Example of Logging in Setting-History Log

For this log, there is selected information that is stored in case of successful as well as unsuccessful setting changes. The following list gives you an overview of this information.

	From top downward: • In the example at the left, a device has started with the active settings group 1. • Then the settings group 1 is selected for changes. • The individual parameter for phase-rotation reversal was changed. • The changes were successfully accepted.

NOTE

- The logged indications are preconfigured and cannot be changed!
- This log, which is organized as a ring buffer, cannot be deleted by the user!
- If you want to archive security-relevant information without loss of information, you must regularly read this log.
- You cannot route additional indication objects to the setting-history log.

3.7.5.6 User Log

With the user-defined log (up to 2), you have the possibility of individual indication logging parallel to the operational log. This is helpful, for example, in special monitoring tasks but also in the classification into different areas of responsibility of the logs. Up to 200 indications can be stored in the user-defined log.

Reading from the PC with DIGSI 5

- To reach the user-defined log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Process Data → Log → User log 1/2

The status of the user-defined log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Read log entries in the headline of the indication list (Figure 3-12 (1)).

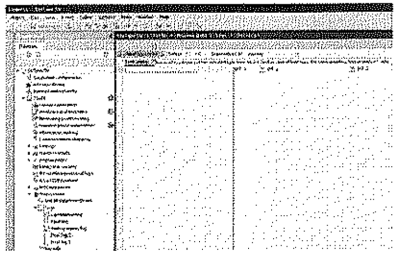

Figure 3-12 Reading the User-Defined Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach user-specific logs from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → User-defined log 1/2

You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-13
Reading the User-Defined Log on the On-Site Operation Panel of the Device

Deletability

The user-defined log of your SIPROTEC 5 device can be deleted. Read about this in chapter 3.7.6 Saving and Deleting the Logs.

Configuration of a User-Defined Log

The indication capacity of a created user-defined log can be configured freely in the associated column of the information routing (matrix) of DIGSI 5:

Target → Log → U1 or U2

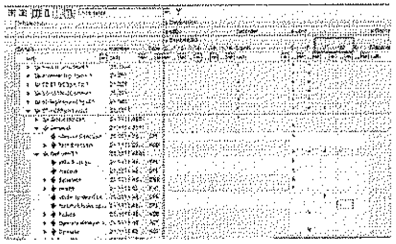

Figure 3-14 Indication Configuration in DIGSI 5 (Example: User-Defined Log U1/2)

3.7.5.7 Communication Log

The logging of the respective status such as ensuing faults, test and diagnostic operation, and communication capacity utilizations is done for all hardware-based configured communication interfaces. Up to 500 indications can be stored in the communication log. Logging occurs separately for each communication port of the configured communication modules.

Reading from the PC with DIGSI 5

- Use the project-tree window to reach the communication logs of your SIPROTEC 5 device.
  Online access → USB → Project → Test suite → Communication module
- Then select:
  J:Onboard Ethernet → Communication log

The status of the communication log last loaded from the device is shown to you under the Time stamp item.

- To update (synchronization with the device) click the button Update in the headline of the indication list.

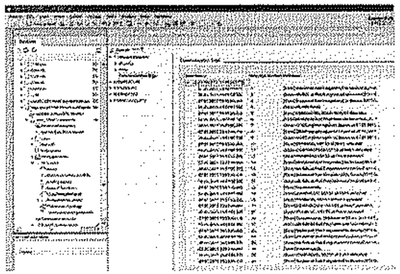

Figure 3-15 Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the communication log from the main menu, use the navigation keys on the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → Communication log
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-16
Reading the Communication Log on the On-Site Operation Panel of the Device

Deletability

The communication logs of your SIPROTEC 5 device can be deleted. Read details about this in chapter 3.7.6 Saving and Deleting the Logs.

Configurability

The communication logs are not freely configurable. The entries are preconfigured.

3.7.5.8 Security Log

Access to areas of the device with restricted access rights is recorded in the security log. Unsuccessful and unauthorized access attempts are also recorded. Up to 500 indications can be stored in the security log.

Reading from the PC with DIGSI 5

- To reach the security log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Device information → Log → Security log

The status of the security log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Update in the headline of the indication list.

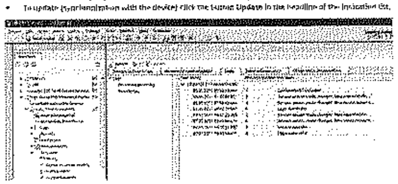

Figure 3-17 Reading the Communication Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the security log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → Security log
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-18
Reading the Security Log on the On-Site Operation Panel of the Device

NOTE

- The logged indications are preconfigured and cannot be changed!
- This log, which is organized as a ring buffer, cannot be deleted by the user!
- If you want to archive security-relevant information without loss of information, you must regularly read this log.

3.7.5.9 Device-Diagnosis Log

The logging and the display of concrete instructions are done in the device-diagnosis log during

- Required maintenance (for example, battery supervision)
- Identified hardware defects
- Compatibility problems

Up to 500 indications can be stored in the device-diagnosis log. In normal operation of the device, it is sufficient for diagnostic purposes to follow the entries of the operational log. This specific significance is assumed by the device-diagnosis log when the device is no longer ready for operation due to hardware defect or compatibility problems and the fallback system is active.

Reading from the PC with DIGSI 5 in Normal Operation

- To reach the device-diagnosis log of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Device information → Log → Device-diagnosis log

The status of the device-diagnosis log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Update in the headline of the indication list.

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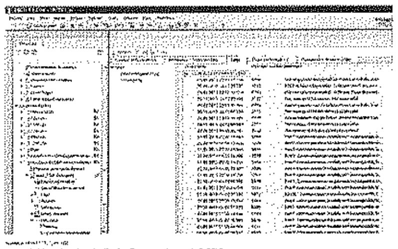

Figure 3-19 Reading the Device-Diagnosis Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel in Normal Operation

- To reach the diagnosis log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Test & Diagnosis → Indications → Device diagnosis
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-20
Reading the Device-Diagnosis Log on the On-Site Operation Panel of the Device

> **NOTE**
> - The device-diagnosis log cannot be deleted!
> - The logged indications are preconfigured and cannot be changed!

3.1.5.10 Motor Starting Log

The motor starting log records the starting current, starting voltage and the start duration each time a motor starts. The motor starting current and the motor starting voltage are displayed as primary values. Up to 200 indications can be stored in the motor starting log.

Measurement of the motor statistics starts when the motor state changes to Start. Measurement of the motor starting time ends as soon as the motor state changes to Standstill or Running. The motor state is obtained from the Motor-state detection function.

No entry is recorded in the motor starting log if the motor state changes to Start and the current drops below the motor starting current within 500 ms.

Table 3-4 Motor Starting Log

Measured Values		Primary
Start duration	Motor starting time	s
Starting current	Motor starting current (primary)	A (or kA)
Starting voltage	Motor-starting voltage (primary)	V (or kV)

Reading from the PC with DIGSI 5

- Use the project tree window to reach the motor starting log of your SIPROTEC 5 device.
  Project → Device → Device information → Log → Motor-starting log

The state of the motor starting log last loaded from the device is shown to you.

- To update (synchronization with the device) click the button Update in the headline of the indication list.

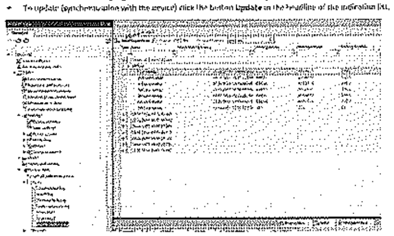

Figure 3-21 Reading the Motor Starting Log with DIGSI 5

Reading on the Device through the On-Site Operation Panel

- To reach the motor-starting log from the main menu, use the navigation keys of the on-site operation panel.
  Main Menu → Indications → **Motor starting log**
- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.

Figure 3-22
Reading the Motor Starting Log on the On-Site Operation Panel of the Device

Deletability

The motor starting log of your SIPROTEC 5 device can be deleted. Read details about this in chapter 3.1.6 Saving and Deleting the Logs.

Configurability

The motor-starting log is only present in the Motor function group. There is no column for the motor-starting log in the DIGSI information matrix. The entries in the motor starting log are preconfigured and cannot be changed.

3.1.6 Saving and Deleting the Logs

Deleting the logs of the device in the operating state is unnecessary. If storage capacity is no longer sufficient for new indications, the oldest indications are automatically overwritten with new incoming events. In order for the memory to contain information about the new faults in the future, for example, after an inspection of the system, a deletion of the log makes sense. Resetting the logs is done separately for the various logs.

> **NOTE**
> Before you delete the content of a log on your SIPROTEC 5 device, save the log with DIGSI 5 on the hard disk drive of your PC.

> **NOTE**
> Not all logs of your SIPROTEC 5 device can be deleted. These restrictions apply especially to logs with relevance for security and after sales (security log, device-diagnosis log, setting-history log).

> **NOTE**
> Upon deletion of the fault log, the associated fault records are also deleted. In addition, the meters for fault number and fault record number are reset to 0. In contrast, if you delete fault records, the content of the fault log, including the allocated fault numbers, remains.

> **NOTE**
> If the device executes an initial start, for example, after an update of the device software, the following logs are automatically deleted:
> - Operational log
> - Fault log
> - Ground-fault log
> - Setting-history log
> - User log
> - Motor-starting log
>
> Back up the deletable logs using DIGSI 5.

> **NOTE**
> If a ground fault is currently active, the ground-fault log cannot be deleted.

Deleting Logs on the On-Site Operation Panel

- To reach the selected log from the main menu, use the navigation keys of the on-site operation panel (example operational log):
  Main Menu → Indications → **Operational log**

Figure 3-23
Deleting the Operational Log on the On-Site Operation Panel

- You can navigate within the displayed indication list using the navigation keys (up/down) on the on-site operation panel.
- The option to delete the entire log is offered to you in the footer of the display at the bottom left. Use the softkeys below under the display to activate the command prompts. Confirm the request to Delete.
- After being prompted, enter the password and confirm with Enter.
- After being prompted, confirm the Deletion of all entries with Ok.

Deleting Logs from the PC with DIGSI 5

- To reach the selected log of your SIPROTEC 5 device, use the project-tree window (for example, operational log).
  Project → Device → Process data → Logs → **Operational log**

3.1.7 Spontaneous Indication Display in DIGSI 5

With DIGSI 5 you have the possibility of displaying all currently transmitted indications of the selected device in a special indication window.

Procedure

- Call up the spontaneous indications of your selected device in the navigation window under Online access.
- Click Indications in the path:
  Online access → Interface → Device → Indications
- The arising indications appear immediately without you having to wait for a cyclical update or initiate the manual update.

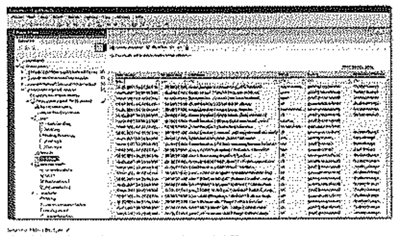

Figure 3-24 Displaying Spontaneous Device Indications in DIGSI 5

3.1.8 Spontaneous Fault Display on the On-Site Operation Panel

After a fault, the most important data of the last fault can be displayed automatically on the device display without further operational measures. In SIPROTEC 5 devices, protected objects and even circuit breakers can be freely created and configured depending on the application (even several instances). In DIGSI 5, several spontaneous fault displays can be configured, depending on the application, with each individual one being assigned a particular circuit breaker. These displays remain stored in the device until they are manually confirmed or reset by LED reset.

Configuration of a Spontaneous Fault Display with DIGSI 5

- To reach the Fault display configuration of your SIPROTEC 5 device, use the project-tree window.
  Project → Device → Display pages → **Fault display configuration**

- In the main window all configured circuit breakers are displayed. A list of a maximum of 6 configurable display lines is offered for each circuit breaker. The activation of a spontaneous fault display occurs for each circuit breaker by selecting the checkmark in the column Display.
- With the parameter (_:139) Fault-display (under Device → Parameter → Device settings) you determine whether spontaneous fault displays should be displayed for each pickup or only pickups with the off command.

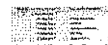

Figure 3-25 Configuration of the Spontaneous Fault Display on the Device

For every display line the following display options can be selected:

Table 3-5 Overview of Display Options

Displayed Information	Explanation
Pickup indication	Display of the first function stage picked up in a fault, as needed with additional information (phases, ground, direction).
PU time	Display of the entire pickup duration of the fault.
Operate indication	Display of the first function stage triggered in a fault, as needed with additional information (phases).
Trip time	Display of the operate time related to the beginning of the fault (pickup start).
Fault distance	Display of the measured fault-location distance.

Acknowledgement of the Spontaneous Fault Display on the Device

After faults, the last occurred fault is always displayed to you. In cases where more than one circuit breaker is configured, several stored fault displays can be present after faults, with the latest being displayed. These displays remain stored in the device until they are manually acknowledged or reset by LED reset.

Figure 3-26
Spontaneous Fault Display on the Device

Method 1: Manual acknowledgement

- Press the softkey button Quit in the base bar of the display. The display is irretrievably closed. Repeat this step until no spontaneous fault display appears anymore.
- After completion of all confirmations the last display view is showed before the faults.

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