9.6 Circuit-Breaker Wear Monitoring

9.6.1 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.

9.6.2 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*-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*-method stage. A maximum of 1 ΣI*-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.

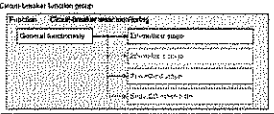

Figure 9-20 Structure/Embedding of the Function

9.6.3 General Functionality

9.6.3.1 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.

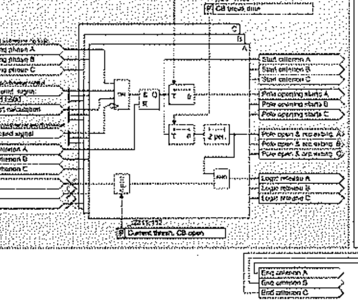

Figure 9-21 Logic Diagram of the Functionality Across Stages of the Circuit-Breaker Wear Monitoring Function

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
  This signal is derived from 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.

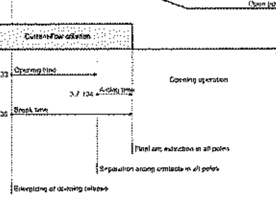

Figure 9-22 Circuit-Breaker Times

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 fulfills 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.

9.6.3.2 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 9-22.

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 9-22.

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.

9.6.3.3 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

9.6.3.4 Information List

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

9.6.4 Stage Description ΣI* Method

9.6.4.1 Description

Logic of the Stage

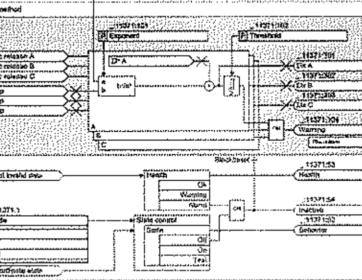

Figure 9-23 Logic of the ΣI*-Method Stage

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 searched for which 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 operation affects only the mechanical lifetime of the circuit breaker and is consequently not considered by this method.

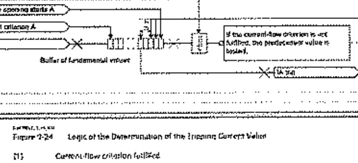

Figure 9-24 Logic of the Determination of the Tripping Current Value

(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.

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

Where:

x	Parameter exponent
q	No. of circuit-breaker switching cycle
$I_{A,trp,q}^x$	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.

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9.6.4.2 Application and Setting Notes

Parameter: Exponent

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

You use the Exponent parameter to specify the exponent for the ΣIx method.

A typical value is the default setting of 2. However, due to practical experiences with individual circuit breakers, slightly different values may be required.

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 ΣIx 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.

9.6.4.3 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

9.6.4.4 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

9.6.5 Stage Description 2P Procedure

9.6.5.1 Description

Logic of the Stage

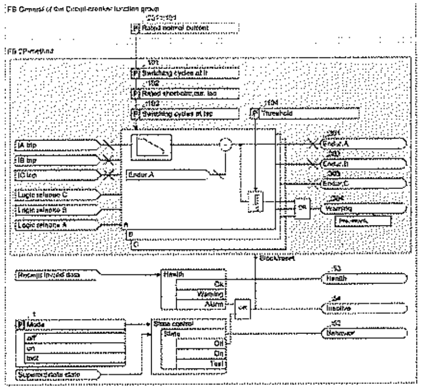

Figure 9-25 Logic of the 2P-Method Stage

Determination of the Tripping/Opening Current Value

For the description to determine the tripping/opening current value, refer to chapter 9.6.4.1 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 determined 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.

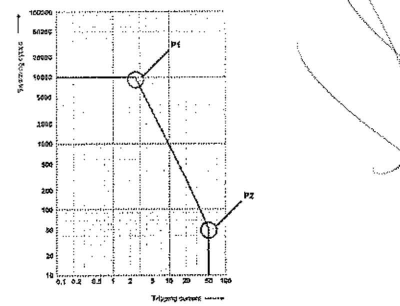

Figure 9-26 Diagram of Switching Cycles for the 2P Method

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.

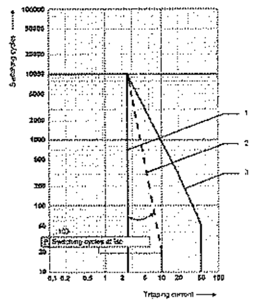

Figure 9-27 Value Limitation of Slope Coefficient

(1) Applied function limit 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 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)
This 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:

$$Endurance = n_{rated} - \left(100 \cdot \frac{n_{rated}}{n_{2.5kA}}\right) - \left(2 \cdot \frac{n_{rated}}{n_{50kA}}\right) - \left(3 \cdot \frac{n_{rated}}{n_{10kA}}\right)$$

$$= 10000 - \left(100 \cdot \frac{10000}{10000}\right) - \left(2 \cdot \frac{10000}{50}\right) - \left(3 \cdot \frac{10000}{681}\right) = 9456$$

There are still 9456 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.

9.6.5.2 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 possible breaking operations with rated short-circuit breaking current is less than 3. For that condition, you set the Threshold value based on the following calculation:

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

9.6.5.3 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

9.6.5.4 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

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9.6.6 Stage Description I²t Method

9.6.6.1 Description

Logic of the Stage

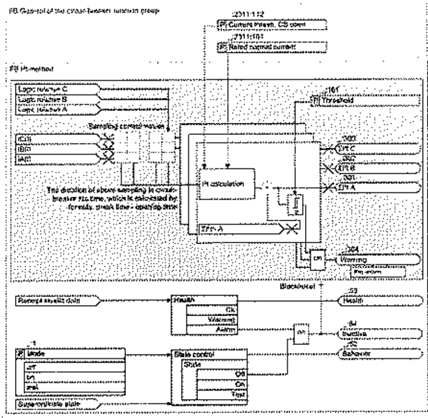

Figure 9-28 Logic of the I²t-Method Stage

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 9-27). 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.

$$I^2t_A = \frac{1}{I_{rated}^2}\int_{Opening\ time}^{Close\ time} i_A^2(t)\,dt$$

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.

9.6.6.2 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.

9.6.6.3 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

9.6.6.4 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

9.6.7 Stage Description Supervision CB Make Time

9.6.7.1 Description

Logic of the Stage

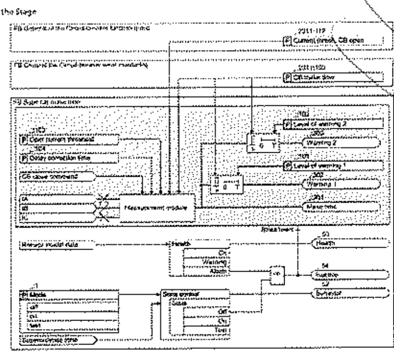

Figure 9-29 Logic of the Supv.CB Make Time Stage

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 Oper. 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 Oper. 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.

9.6.7.2 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.

9.6.7.3 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		0.000 s to 0.050 s	0.000 s

9.6.7.4 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

9.7 Average Values

9.7.1 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 value (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 synchroniz. 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 Φ, 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 5.2 Structure of the Function Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):
>
> - Active power (mean) P total
> - Reactive power (mean) Q total

9.7.2 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

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

Parameter: Average synchroniz. time

- Default setting: (_:104) 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 at 12:03:25, 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 at 12:03:25, 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 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 11:10:00.

9.8 Minimum/Maximum Values

9.8.1 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.

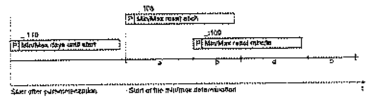

Figure 9-38 Minimum and Maximum-Value Formation

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 min/max
- 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 9.2 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:
  MinPtotal, MaxPtotal, MinQtotal, MaxQtotal
- Minimum/maximum values of the average values of the active and reactive power
  AverageMinPtotal, AverageMaxPtotal, AverageMinQtotal, AverageMaxQtotal

9.8.2 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 used 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)

9.9 Energy Values

9.9.1 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:

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

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 (>Reset energy) 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 9.2 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-

9.9.2 Application and Setting Notes for Energy Values

The set parameters apply for all electricity 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 Value	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: (_:120) 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

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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.

9.10 User-Defined Metered Values

9.10.1 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
  Time-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 9-31). Select the metered value and enter the settings under **Properties**.

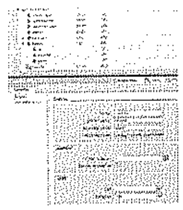

Figure 9-31 Setting with DIGSI, General Settings, Pulse-Metered Values

9.10.2 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.

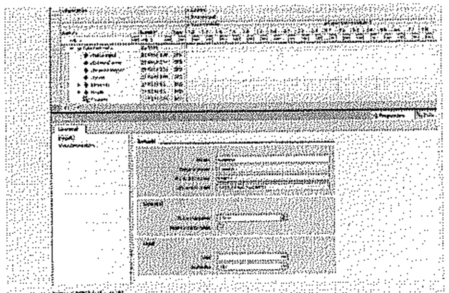

Figure 9-32 Setting with DIGSI

9.11 Statistic Values

9.11.1 Statistical Values of the Primary System

The device has 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)

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9.12 Measuring Transducers

9.12.1 Overview of Functions

Measuring transducers with an input rated at 20 mA can be used in the devices. 4 such inputs are available at 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 variable such as temperature or gas pressure are recorded with such 20-mA measured values and reported to the substation automation technology.

9.12.2 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.

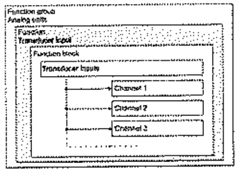

Figure 9-33 Structure/Embedding of the Function

9.12.3 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.

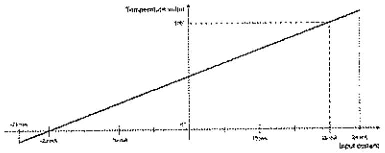

Figure 9-34 Characteristic Curve of a 20-mA Input (Example 1)

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.

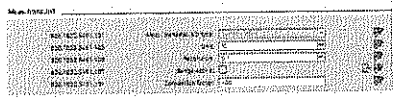

Figure 9-35 Settings for Example 1

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 measured are valid (see following figure).

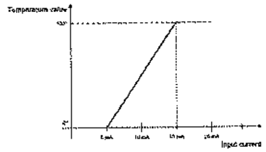

Figure 9-36 Characteristic Curve of a 20-mA Input (Example 2)

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. This 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.

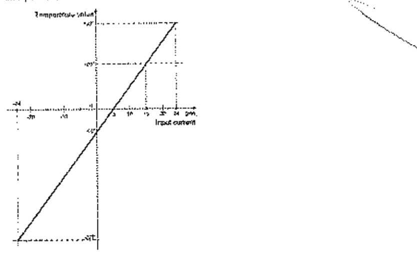

Figure 9-37 Total Characteristic Curve in Example 2

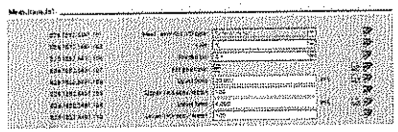

Figure 9-38 Settings for Example 2

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.

9.12.4 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 (_:109) 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.

9.12.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT in #				
_:101	MT in #:Meas. transduc. 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		• % • ' • °C • °F • Ω • Ω/km • Ohm • 1/s • A • As • cos φ • cycles • dB • F/km • F/m² • h • Hz • l/hr • in • J • kWh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • 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 10000	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

Addr.	Parameter	C	Setting Options	Default Setting
_:110	MT in #:Lower limit - Sensor		-10000 to 10000	100

9.12.6 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

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10 Functional Tests

10.1 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 locked 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.

10.2 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 point of 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 or closure, a fault record at 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 10-1).
  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.

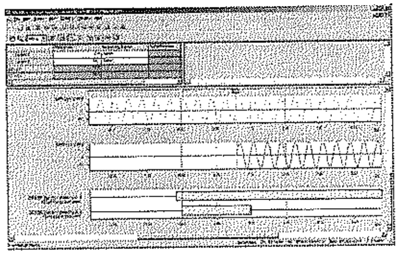

Figure 10-1 Measurement of the Circuit-Breaker Closing Time

2. The arrangement in Figure 10-2 is suitable for measuring the circuit breaker operating time with external timer. Set the timer to the range 1 s or a stepping 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_{Line} 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.

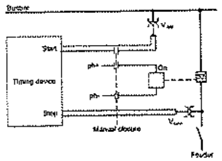

Figure 10-2 Measurement of the Circuit-Breaker Closing Time

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 time for oversynchronous 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 activation 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.

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10.3 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 NOT 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 7.1.4 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-external 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 7.1.4 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.
- Activate 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.

Start by Trip Command from the External Protection

- Check the static and – in case of dynamic 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 operational 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 on 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.

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.

10.4 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 connections.

As a final step, switch off the system.

10.5 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-pole open/close cycle

Structure of the Function

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

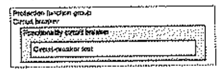

Figure 10.3 Embedding of the Function

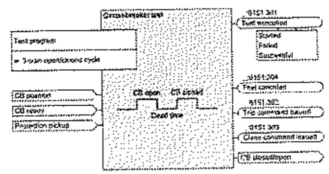

Figure 10.4 Structure of the Function

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 picked up in the circuit-breaker protection function group responsible for the circuit breaker.

Figure 10.5 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 positions 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 (_:4201:101) 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.

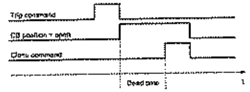

Figure 10.5 Progression over Time of a Circuit-Breaker Test Cycle

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 group for circuit breakers. This may cause stability problems in the system during a 3-pole trip-reclose. Therefore, a 3-pole circuit-breaker test should be only done, 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.

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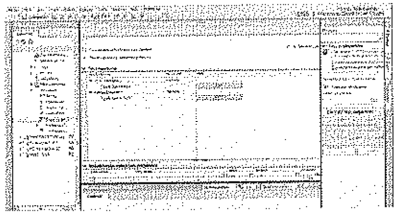

[illegible]
Figure 10-6 Circuit-Breaker Test in the Test Suite in DIGSI

- 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.

10.6 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: 100/1 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.

10.7 Functional Test of Thermal Overload Protection

Secondary Test

For the secondary test for the overload protection, note that the 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 $1.5 \cdot I_{rated,obj}$

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

$I_{rated,obj.} = 483$ A

$I_{rated,prim}$ = 750 A

$I_{rated,sec}$ = 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 $I_{preload}$ = 0. The setting parameters must be the K-factor (for example, 1.1) and the Thermal time constant (for example, 600 s or 10 min).
- Test from the cold state.

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

[illegible]

- 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 ($I_{preload} = I_{rated,obj}$) 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 ($1.5 \cdot I_{rated,obj}$), the overload protection will trip in the following time.

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

[illegible]

-

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.

10.8 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.

10.9 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.

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11 Technical Data

11.1 General Device Data

11.1.1 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
	5 A	0 A to 500 A
	1 A	0 A to 100 A
Instrument transformers	5 A	0 A to 8 A
	1 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
Comments:	
[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 11-1 High-Speed Measuring-Transducer Inputs, Voltage

Differential voltage input channels	8 [3]
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 11-2 High-Speed Measuring-Transducer Inputs, Current

Differential current input channels	8 [4]
Measuring range	DC -20 mA to +20 mA

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

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

11.1.2 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	34 VA	24 VA
1/6 expansion module	3 W	6 VA	6 VA
1/6 plug-in module assembly without plug-in modules (modular 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	

11.1.3 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.		

11.1.4 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)	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	≤ 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 Max. bounce: ≤ 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	1000 W	In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
220 V/4.5 A	1000 W	
110 V/5.0 A	550 W	
60 V/5.0 A	300 W	
48 V/5.0 A	240 W	
24 V/5.0 A	120 W	
From no 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.		
110 V/8.0 A	1000 W	Continuous and limiting 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.
60 V/10.0 A	600 W	
48 V/10.0 A	480 W	
24 V/10.0 A	240 W	
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.		

11.1.5 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	8.2 kg	12.0 kg	15.9 kg	19.3 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	3.7 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 [7] (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 [7] (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)

[7] Width and depth rounded to whole numbers in mm
[7] Width and depth rounded to whole numbers in mm

Type of Construction (Maximum Dimensions)	Width over all x Height over all x Depth [7] (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 [8] (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)

[7] Width and depth rounded to whole numbers in mm
[8] 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
Stranded 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

11.2 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	17 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	18 ms
For 6 ends	Minimum	17 ms
	Typical	23 ms
Dropout times, total approx.		
For 2 ends	Typical	24 ms
For 3 ends	Typical	26 ms
For 6 ends	Typical	32 ms

Priority 3[3]		
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

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

11.3 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)[4]
	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]

[4] If provided

11.4 Automatic Reclosing

Function specification	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 oo (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 oo (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 oo (ineffective)	Increments of 0.01 s
Dead-line check/reduced dead time	Without	
	Reduced dead time (RDT)	
	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

11.5 Phasor Measurement Unit

Accuracy

As per IEEE Std C37.118.1a-2014

Synchrophasor Standard

IEEE Std C37.118.1-2011

11.6 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 Irated²s to 21 400 000.00 Irated²s	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 @ 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

11.7 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 [5]

Tolerance

Sequence tolerance for delay times	1 % of the setting value or 10 ms

[5] [illegible]

11.8 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[22]	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[23] 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

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances

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

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)[24] (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 %)[25]
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 %)[26]
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 %)[27]
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 %

[24] In case that the filter response exactly matches the user-defined gain factors
[25] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.
[26] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.
[27] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.

11.9 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

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

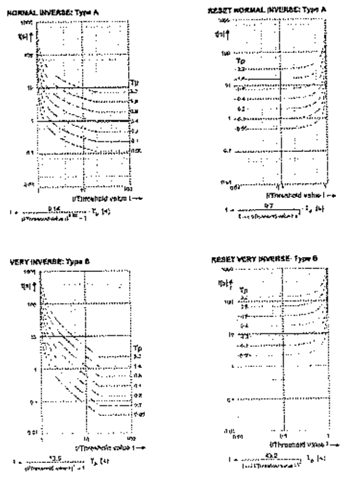


Figure 11-1 Operate Curves and Dropout-Time Characteristic Curves According to IEC

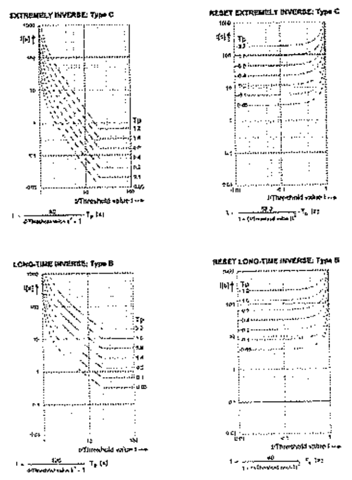


Figure 11-2 Operate Curves and Dropout-Time Characteristic Curves According to IEC

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

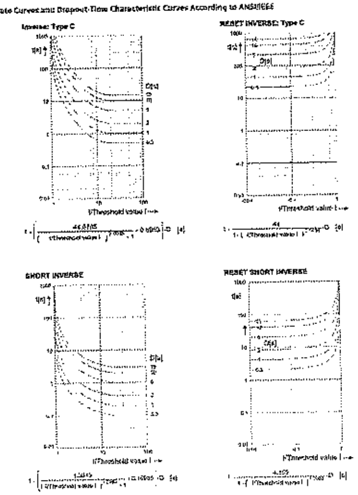


Figure 11-3 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

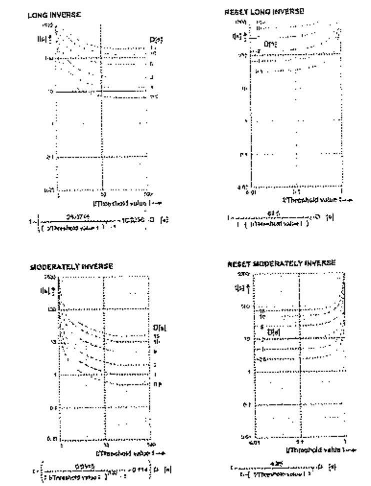


Figure 11-4 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

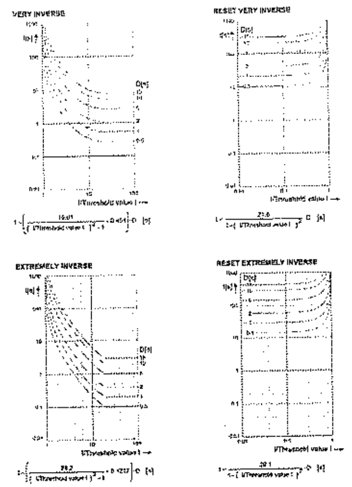
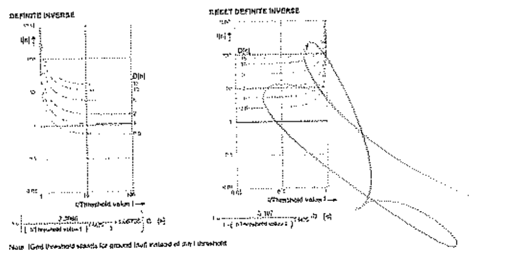


Figure 11-5 Tripping Characteristic Curves and Dropout Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead of an I threshold

Figure 11-6 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
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, 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[24] (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 %)[25]
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 %)[26]
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 %)[27]
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 %

[illegible footnotes]

11.10 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	-
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
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, 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[28] (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 %)[29]
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 %)[30]
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 %)[31]
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

[illegible footnotes]

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Technical Data

Influencing Variables for Thresholds

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

11.11 Definite-Time Overcurrent Protection, Ground

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value[1]	1 A @ 50 and 100 Irated	0.010 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 greatest dropout difference (= | pickup value – dropout value |) of the following 2 criteria applies:

Dropout difference 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 difference	
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[2] 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

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10 Hz \leq f < 0.9 f_{rated}$ $1.1 f_{rated} < f \leq 80 Hz$	Slightly expanded tolerances[3]
f < 10 Hz f > 80 Hz	Active

Tolerances

3I0 measured via I4[3], method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (I_{rated} ≥ 10 %)

[1] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$.
[2] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs
[3] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2

3I0 measured via I4[3], 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), (I_{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), (I_{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), (I_{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 imbalance)	< 5 %

[3] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2

11.12 Stage with Inverse-Time Characteristic Curve

Setting Values

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		Disk emulation Instantaneous	-
Time multiplier		0.00 to 15.00	Increments of 0.01
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

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

[4] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$.

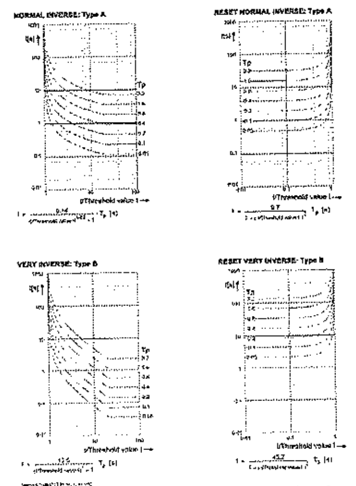

Figure 11-7 Operate Curves and Dropout-Time Characteristic Curves According to IEC

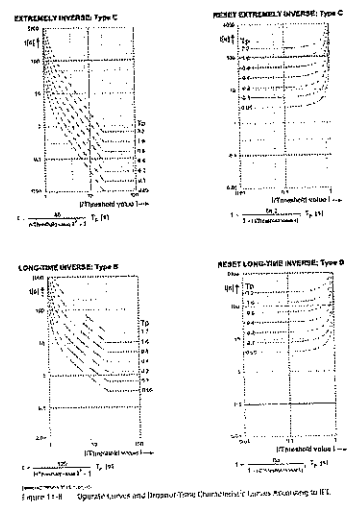

Figure 11-8 Operate Curves and Dropout-Time Characteristic Curves According to IEC

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Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

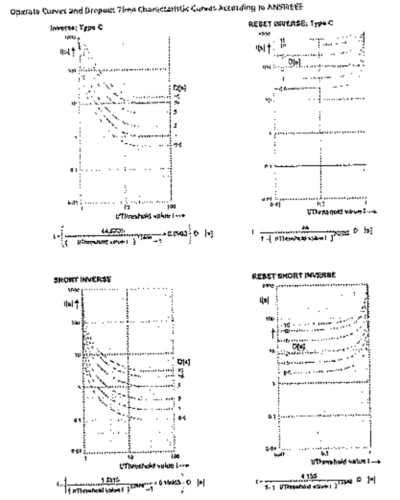


Figure 11-9 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

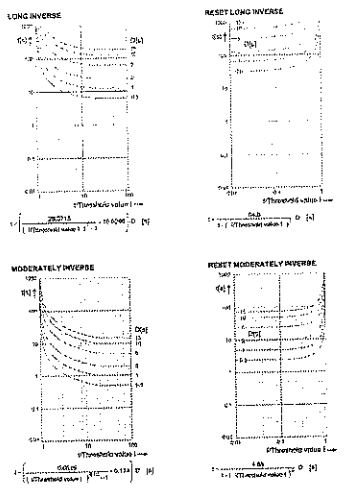


Figure 11-10 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

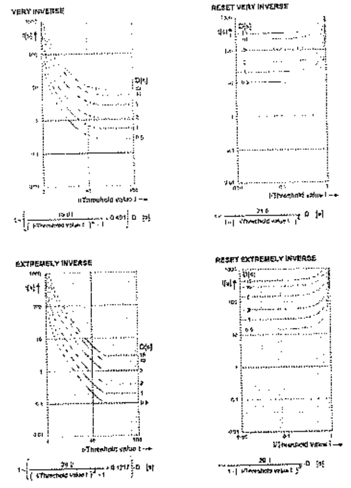
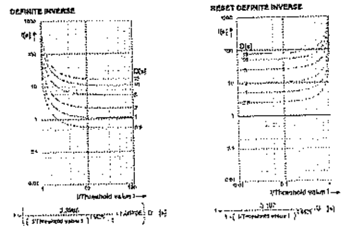


Figure 11-11 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead of the I threshold

Figure 11-12 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 $\le f <$ 0.9 f_{rated} 1.1 $f_{rated} < f \le$ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

3I0 measured via I4[1], 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[2], 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

[1] [illegible]
[2] [illegible]

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 %

11.13 Overcurrent Protection, Ground 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 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 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 Ratio

Disk emulation	Approx. 0.90 * threshold value
Instantaneous	Approx. 1.05 * threshold value Approx. 0.95 * pickup value

Dropout

The greater dropout difference (= | pickup value − dropout value |) of the following 2 criteria applies

Dropout difference 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 difference	
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 $\le f <$ 0.9 f_{rated} 1.1 $f_{rated} < f \le$ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

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Y values of the dropout characteristic curve	0.00 s to 999.00 s	Increments of 0.01 s

Dropout Ratio for Stage Type with User-Defined Characteristic Curve (Inverse Time)

Disk emulation	Approx. 0.90 * threshold value
Time multiplier	Approx. 1.05 * threshold value Approx. 0.95 * pickup value

Tripping and Dropout Characteristic Curves

You can select from the following tripping and dropout characteristic curves:

Table 11-3 Standard characteristic curves to IEC

Normal inverse: type A	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-1
Very inverse: type B	
Extremely inverse: type C	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-2
Long-time inverse	

Table 11-4 Standard characteristic curves to ANSI/IEEE

Inverse: type C	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-3
Short inverse	
Long inverse	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-4
Moderately inverse	
Very inverse	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-5
Extremely inverse	
Definite inverse	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-6

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

Dropout

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

Dropout difference 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 difference	
Protection class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)

11.14 Directional Time-Overcurrent Protection, Phases

Setting Values for the Function

Rotation angle of the reference voltage	-180° to +180°	Increments of 1°

Setting Values for All Stage Types

Directional mode		Forward Backward	-
Method of measurement		Fundamental component RMS value	-
Threshold value[1]	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	0.030 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.15 A to 8.000 A	Increments of 0.001 A

Setting Values for the Definite Time-Overcurrent Protection Stage Type

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

Setting Values for the IEC/ANSI Characteristic Curve Stage Type (Inverse-Time)

Type of characteristic curve	Characteristic curves according to IEC (see Table 11-3) and ANSI (see Table 11-4)	
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 to 60.00 s	Increments of 0.01 s

Dropout Ratio for the IEC/ANSI Characteristic Curve Stage Type (Inverse-Time)

Disk emulation	Approx. 0.90 * threshold value
Time multiplier	Approx. 1.05 * threshold value Approx. 0.95 * pickup value

Setting Values for Stage Type with User Defined Characteristic Curve (Inverse Time)

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 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 to 0.95 p.u.	Increments of 0.01 p.u.

[1] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 I_{rated}.

Tolerances

3I0 measured via I4[2], 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[3], 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 the 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

[2] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2
[3] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

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. 37 ms + OOT[4] at 50 Hz Approx. 32 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 %)
Definite-time operate time	1 % of the setting value or 10 ms
Inverse-time operate time according to IEC, ANSI, user-defined characteristic curve	5 % of the setting value or +2 % current tolerance or 10 ms
Inverse-time dropout time according to IEC, ANSI, user-defined characteristic curve	5 % of the setting value or +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 %

[4] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

11.15 Directional Time-Overcurrent Protection, Ground

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 for All Stage Types

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	0.030 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.15 A to 8.000 A	Increments of 0.001 A

Setting Values for Stage Type Definite Time-Overcurrent Protection

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

Setting Values for Stage Type Inverse Time-Overcurrent Protection (IEC/ANSI)

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
Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 to 60.00 s	Increments of 0.01 s

Dropout Values for Stage Type Inverse Time-Overcurrent Protection (IEC/ANSI)

Disk emulation	Approx. 0.90 * threshold value
Instantaneous	Approx. 1.05 * threshold value Approx. 0.95 * pickup value

Characteristic Curves for Stage Type Inverse Time-Overcurrent Protection (IEC/ANSI)

Standard Characteristic Curves According to IEC

Normal inverse: type A	Refer to the respective picture of the technical data for the non-dir. OC ground function 11.12 Stage with Inverse-Time Characteristic Curve
Very inverse: type B	
Extremely inverse: type C	
Long-time inverse	

Standard Characteristic Curves According to ANSI/IEEE

Extremely inverse: type C	Refer to the respective picture of the technical data for the non-dir. OC ground function 11.12 Stage with Inverse-Time Characteristic Curve
Long time inverse: type B	
Long-time inverse	
Moderately inverse	
Very inverse	
Extremely inverse	
Uniformly inverse	

Setting Values for Stage Types Logarithmic Inverse Time-Overcurrent Protection

Characteristic curve: see Figure 11-13		
Threshold value multiplier	1.00 to 4.00	Increments of 0.01
Time multiplier	0.05 to 15.00	Increments of 0.01
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

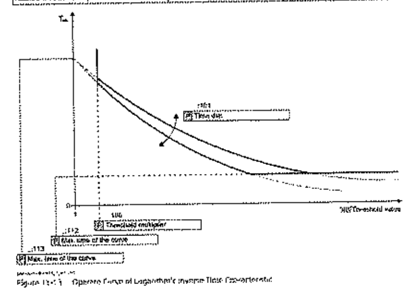

Figure 11-13 Operate Curve of Logarithmic Inverse Time Characteristic

Dropout value for Stage Types Logarithmic Inverse Time-Overcurrent Protection

Dropout ratio	Approx. 1.05 * threshold value Approx. 0.95 * pickup value

Setting Values for Stage Type Logarithmic Inverse Time with Knee-Point Overcurrent Protection

Characteristic curve, see Figure 11-14		
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

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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	0.001 A
Current at minimum time of the curve	0.030 A to 35.000 A	0.001 A
Time factor	0.05 to 15.00	Increments of 0.01

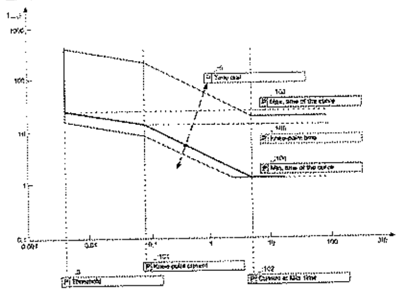

Figure 11-14 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (in the Example of Threshold = 0.004 A)

Dropout value for Stage Type Logarithmic Inverse Time with Knee-Point Overcurrent Protection

Dropout ratio	Approx. 0.95 * threshold value

Setting Values for Stage Type User-Defined Characteristic Curve Overcurrent Protection

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 0.99 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 Values for Stage Type User-Defined Characteristic Curve Overcurrent Protection

Disk emulation	Approx. 0.90 * threshold value

Instantaneous	Approx. 1.05 * threshold value Approx. 0.95 * pickup value

Dropout

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

Dropout difference 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 difference	
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. 20 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

$0.9 \leq f/f_{rated} \leq 1.1$	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 with reduced sensitivity

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)
Currents, method of measurement = RMS value (33 % part of 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 %)
	Up to 50th 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 %)
Definite-time operate time	1 % of the setting or 10 ms
Inverse-time operate time to IEC, ANSI, logarithmic inverse time characteristic, logarithmic inverse time with knee-point characteristic, and user-defined characteristic curve	5 % of setting value or +2 % current tolerance or 30 ms

Inverse-time dropout time to IEC, ANSI, logarithmic inverse-time characteristic, logarithmic inverse time with knee-point characteristic, and user-defined characteristic curve	5 % of setting value or +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 %

11.16 Inrush-Current Detection

Setting Values

Operating range limit I_{max}	0.030 A to 35.000 A at I_{rated} = 1 A 0.15 A to 175.00 A at I_{rated} = 5 A	Increments of 0.001 A Increments of 0.01 A
Component of 2nd harmonic	10 % to 45 %	Increments of 1 %
Duration of the crossblock function	0.03 s to 200.00 s	Increments of 0.01 s

Times

Pickup times	Approx. 29 ms

Dropout Ratios

Harmonics $I_{2nd\ harm}/I_{1st\ harm}$	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

$0.9 \leq f/f_{rated} \leq 1.1$	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

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

11.17 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[1]

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

[1] OOT (Output Operating Time) Additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.18 Overcurrent Protection, 1-Phase (Stage with Definite Time-Overcurrent Protection)

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[1]	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
Dropout ratio (fixed)		0.95	–
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout difference (= | pickup value − dropout value |) of the following 2 criteria applies.

Dropout difference 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 difference	
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[2] 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

$0.9 \leq f/f_{rated} \leq 1.1$	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 %)

[1] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$
[2] OOT (Output Operating Time) Additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

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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 %

11.19 Overcurrent Protection, 1-Phase (Stage Inverse Time-Overcurrent Protection)

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value[1]	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
Dropout		Disk emulation instantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01

Dropout

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

Dropout difference 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 difference	
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)

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 ≤ 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 %)

[1] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.3 I_{rated}.

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 %

11.20 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[2]	1.01 to 1.20	Increments of 0.01
Undervoltage threshold value[2]	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[2]	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[2]	150 mV sec.

Reset of the Integration Timer for Inverse Time-Overcurrent Stages

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

[2] [illegible]

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 %

11.21 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[1]	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

[1] 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[2] 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 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

[2] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.22 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 difference (= | pickup value – dropout value |) of the following 2 criteria applies:

Dropout difference derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout difference	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[3] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

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	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[3] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.23 Overvoltage Protection with Any Voltage

Setting Values

Measured value[4]	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 voltage VN 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[5]	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 difference (= | pickup value – dropout value |) of the following 2 criteria applies:

Dropout difference derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout difference	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[6] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

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	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[4] If the function Overvoltage protection with any voltage is used in a 1-phase function group, the Measured value parameter is not visible.
[5] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.
[6] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.24 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[7]		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)

[7] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.

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$$T_{Inv} = T_p\left(\frac{k}{1-\left(\frac{V}{V_{thresh}}\right)^{\alpha}} + c\right)$$

[illegible]

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 difference (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout difference derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout difference	150 mV sec.

Times

Pickup time	Approx. 25 ms + OOT[1] 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
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	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

[1] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 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

11.25 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} Measured voltage V0 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[2]	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 difference (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout difference derived from the parameter Dropout ratio If the parameter is not available, a dropout ratio of 95 % applies for overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout difference	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[3] 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
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	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

[2] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.
[3] OOT (Output Operating Time) additional delay of the output medium used, see chapter 11.1.4 Relay Outputs

Time delays	1 % of the setting value or 10 ms

11.26 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 60 Hz	Approx. 70 ms + OOT[4] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 75 ms + OOT 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

[4] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter 11.1.4 Relay Outputs

11.27 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 60 Hz	Approx. 70 ms + OOT[5] Approx. 60 ms + OOT
	Filtering method	
	50 Hz 60 Hz	Approx. 75 ms + OOT 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

[5] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter 11.1.4 Relay Outputs

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11.28 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

$0.9 \le f/f_{rated} \le 1.1$	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

Threshold, measuring window > 3 periods	Approx. 1 % 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

11.29 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[1] 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 $0.8 \le V_{aux}/V_{aux,rated} \le 1.15$	≤ 1 %
Frequency in the range $0.95 \le f/f_{rated} \le 1.05$	≤ 1 %
Harmonics - Up to 10 % of 3rd harmonics - Up to 10 % of 5th harmonics	 ≤ 1 % ≤ 1 %

[1] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.30 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

11.31 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	3-pole tripping internal or external[2]

Setting Values

Phase-current threshold values	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.000 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 0.001 A
Sensitive threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 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 0.001 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).

Times

Pickup time, in the case of an internal start	< 1 ms
Pickup time, in the case of an external start	< 5 ms
Typical dropout time	< 15 ms
Dropout time via circuit breaker auxiliary-contact criterion	< 5 ms

[2] Via binary inputs

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

Threshold values, dropout thresholds	2 % of the setting value or 1 % of the rated current
Times	1 % of the setting value or 10 ms

11.32 Negative-Sequence Protection 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
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
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

Times

Pickup times	Approx. 35 ms + OOT
Dropout times	Approx. 35 ms + OOT

Dropout Ratio

Pickup value	Approx. 0.95 for I_2/I_{ref} ≥ 0.3

Operating Ranges

Current range	$0.05 \times I_{rated,obj.}$ ≤ all phase currents ≤ setting value $I_{ph,max}$
Frequency range	10 Hz to 80 Hz

Tolerances

Pickup value	
$I_2/I_{rated,obj.}$	Approx. 2 % of the setting value or 0.6 % absolute value (transformer mismatching < 4)
I_2/I_1	Approx. 2 % of the setting value or 1 % absolute value (I_1 > [illegible] mA (1 A) or 250 mA (5 A))
Time delays	1 % of the setting value or 10 ms

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11.33 Stage with Inverse-Time Characteristic Curve

Setting Values

Reference value for 1 (I_{ref})		Rated object current $I_{rated,obj}$	
		Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % 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 1 % of the object rated current

Times

Pickup time	Approx. 40 ms + OOT[1] 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

Operate and Dropout Characteristic Curves

You can select from the following operate and dropout characteristic curves:

Table 11-5 Standard Characteristic Curves to IEC

Normal inverse: type A	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-1
Very inverse: type B	
Extremely inverse: type C	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-2
Long-time inverse: type B	

[1] OOT (Output Operating Time) additional delay of the output medium used, see chapter 11.1.4 Relay Outputs

Table 11-6 Standard Characteristic Curves to ANSI

Inverse: type A	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-3
Short inverse	
Long inverse	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-4
Moderately inverse	
Very inverse	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-5
Extremely inverse	
Definite inverse	See chapter 11.9 Stage with Inverse-Time Characteristic Curve, Figure 11-6

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_{pickup}
	All phase currents < setting value I_{pickup}

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	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

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

11.34 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.

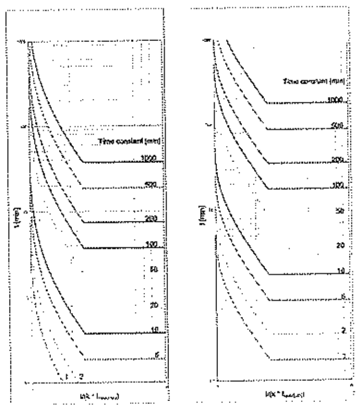
Tolerances

No filter applied (11 % 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 · 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

[1] In case that the filter response exactly matches the user-defined gain factor.
[2] In case that the user-defined gain factor is set below 1. The tolerance is increased if the gain factor is larger.
[3] In case that the user-defined gain factor is set below 1. The tolerance is increased if the gain factor is larger.



With 90 % preload and with $I_{th,warn}$ = 2.5 * k * I_{rated}

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \quad [min]$$

Without preload and with $I_{th,warn}$ = 2.5 * k * I_{rated}

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \quad [min]$$

Figure 11-15 Operate Curve of Overload Protection

11.35 Temperature Supervision

Setting Values

Pickup value	-50 °C to 250 °C	Increments of 1°C
	-58 °F to 482 °F	Increments of 1°F
Time delay	0 s to 60 s	Increments of 1 s
	or ∞	

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

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11.36 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

11.37 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, change-over threshold 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°
df 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 V2 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 α2-α1 • 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

11.38 Arc Protection

Setting Values

Threshold I>	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 @ 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 @ 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 @ 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[78]
Shortest operate time Operating mode = Current and light	Approx. 4.0 ms + OOT at 50 Hz Approx. 3.8 ms + OOT at 60 Hz

[78] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with a fast relay, see Chapter 11.1.4 Relay Outputs

11.39 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 (max)	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		
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
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
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 ever measured (referenced to phase-to-phase)	kV	V	Maximum voltage of the winding referenced to the rated voltage of the winding
V min	Minimum positive sequence voltage ever measured (referenced to phase-to-phase)	kV	V	Minimum voltage of the winding referenced to the rated voltage of the winding
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

ВЯРНО С ОРИГИНАЛА

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 ctrl.	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

11.40 Current-Balance Supervision

Setting Values

Release threshold value	I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
	I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
Threshold value minimum		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

11.41 Voltage-Balance Supervision

Setting Values

Release threshold value	0.300 V to 170.000 V	Increments of 0.001 V
Threshold value minimum	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

11.42 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

11.43 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

11.44 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

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11.45 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

11.46 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 0,05 s
Adjustable indication delay with 2 binary inputs	1,00 s to 600,00 s	Increments of 0,05 s

11.47 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).

11.48 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[1] 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[2] at 50 Hz Approx. 9 ms + OOT at 60 Hz

Use in other function group types	
Pickup time	Approx. 24 ms + OOT[3] at 50 Hz Approx. 18 ms + OOT at 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

[1] OOT (Output Operating Time) Additional delay of the output medium used, see chapter 11.1.1 Relay Outputs
[2] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter 11.1.4 Relay Outputs
[3] OOT (Output Operating Time) Additional delay of the output medium used, for example 5 ms with fast relays, see chapter 11.1.4 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

11.49 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 component.
- 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

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Currents, Protection Class Current Transformer

I_A, I_B, I_C, $3I_0$	A secondary
Current range	≤ 100 I_{rated}
Rated currents	1 A, 5 A
Measuring range	0.1 to 25 A
Frequency range	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	0.5 % of the measured value in the above mentioned measuring range

Currents, Sensitive Ground-Current Transformer

$3I_0$	A secondary
Current range	≤ 1.6 I_{rated}
Rated currents	1 A, 5 A
Measuring range	(0.1 to 1.6) · I_{rated}
Frequency range	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	0.5 % 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	|cosφ| ≥ 0.01
Voltage range	(0.8 to 1.2) · V_{rated}
Current range	(0.1 to 2) · I_{rated}
Frequency range	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	|cosφ| ≤ 0.984
Voltage range	(0.8 to 1.2) · V_{rated}
Current range	(0.1 to 2) · I_{rated}
Frequency range	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	(0.01 to 2) · S_{rated}
Voltage range	(0.8 to 1.2) · V_{rated}
Current range	(0.01 to 2) · I_{rated}
Frequency range	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
ΣI 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

11.50 Energy Values

Setting Values

Active energy W_p Reactive energy W_q	kWh, MWh, GWh kvarh, Mvarh, Gvarh
Range	≤ 2% for I > 0.1 I_{rated} V > 0.1 V_{rated} |cosφ| ≥ 0.707
Tolerance at rated frequency	1 %

11.51 CFC

Typical response times and maximum number of ticks of the CFC task levels

Task Level	Time (in ms)	Ticks CP200	Ticks CP300
Fast Event-Triggered	<1	1500	3000
Event-Triggered	<10	13059	15 006
Interlocking	<10	123 927 in total	144 022 in total
Measurement	250		

The times describe the response time of a typical CFC chart at the respective task level. In the maximum number of ticks applies to a typical load for the device based on the application template 6MD85 Standard (Double busbar feeder with switchgear interlocking protection).

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:

$$T_{Chart} = 5 \cdot n_{Inp} + 5 \cdot n_{Outp} + T_{TLev} + \sum_i T_{Int} + \sum_j T_{Block}$$

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_{Int} Number of internal connections between 2 CFC blocks in one chart

T_{Block} Used ticks per CFC block (see Technical Data)

Table 11-7 Ticks of the Individual CFC Blocks

Element	Ticks
ABS_D	2.1
ABS_R	1.5
ACOS_R	6.9
ADD_D4	4.4
ADD_R4	3.3
ADD_XMV	6.4
ALARM	1.8
AND_SPS	1.1
AND16	2.9
APC_DEF	1.2
APC_EXE	1.8
APC_INFO	3.9
ASIN_R	1.3
ATAN_R	1.2
BLINK	1.1
BOOL_CNT	2.0
BOOL_INT	1.5
BSC_DEF	1.3
BSC_EXE	1.1

Element	Ticks
BSC_INFO	2.7
BUILD_ACD	2.9
BUILD_ACT	2.7
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	3.2
BUILD_XMV	2.9
BUILDC_Q	3.0
CHART_STATE	5.9
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
DPS_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	0.4
FF_D	0.9
FF_D_MEM	1.4
FF_RS	0.7
FF_RS_MEM	1.2
FF_SR	0.8
FF_SR_MEM	1.1
GE_D	0.9

Element	Ticks
GE_R	1.1
GT_D	0.9
GT_R	1.1
HOLD_D	1.1
HOLD_R	1.0
INC_INFO	0.9
LE_D	1.1
LE_R	1.1
LIML_R	1.5
LIMU_R	1.5
LN_R	2.3
LOG_R	1.7
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
NAND4D	1.5
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
NOR4D	3.2
OR_DYN	1.1
OR_SPS	1.3
OR4D	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
SPC_EXE	0.4
SPC_INFO	0.4

Element	Ticks
SPC_OUT	0.4
SPLIT_ACD	2.4
SPLIT_ACT	1.0
SPLIT_BSC	1.5
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	2.7
SQRT_R	0.6
SUB_D	1.3
SUB_R	1.6
SUB_XMV	2.4
SUBST_B	1.0
SUBST_BC	1.5
SUBST_D	1.9
SUBST_R	1.0
SUBST_XQ	1.4
SXMV_REAL	3.0
TAN_R	1.1
TLONG	2.7
TOF	1.0
TON	1.3
TP	2.5
TSHORT	1.9
UINT_DINT	3.0
XOR2	2.6

A Anhang

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[8]
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 (0120)[8]
Terminal	Terminal kit only for x02302[8]
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 7KE85

[8] [illegible]

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

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 9:1, for example, stands for the address of the setting parameter
Error	Parameter state

The following symbols are used in drawings:

Icon	Description
_:691:41 Stage blocked	Parameter
_:661:1 Mode off on test	Parameters with setting values The default setting is in the 1st position and displayed in italics
_:4661:2 Operate & flt.rec. blocked Dynam. setting 1st	Parameters with application-dependent setting values
_:4861:3 Threshold	Dynamic settings
State control State Off On Test	Static logic
Health Ok Warning Alarm	Health of a function, stage, or function block
_:501:84 >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
_:3451:300 I diff.	Measured output value

Icon	Description
_:51 Test mode	Binary input signal derived from an external output signal
Meas. volt. failure	Internal input signal
Blocked stage	Internal output signal
Frequency	Analog input signal
?	Reset/Block a logic element
AND	AND gate
OR	OR gate
XOR	XOR gate
AND	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	SR flip-flop, RS flip-flop, D flip-flop
	Characteristic curve
	Minimum operate time

A.4 Standard Variants for 6MD85

Type 1

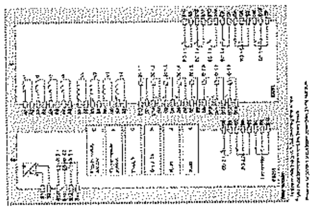

Figure A.1 Standard Variant Type 1

Type 2

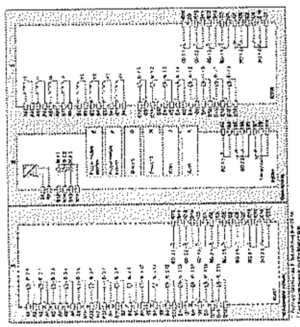

Figure A.2 Standard Variant Type 2

Type 4

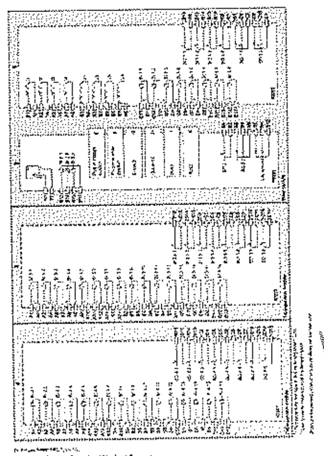

Figure A.3 Standard Variant Type 4

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Type 4

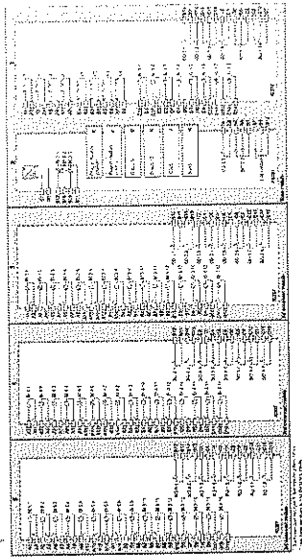

Figure A-4 Standard Variant Type 4

Type 7

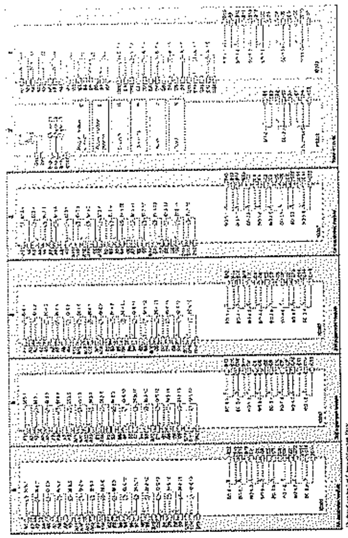

Figure A-5 Standard Variant Type 7

A.5 Standard Variants for 6MD86

Type 1

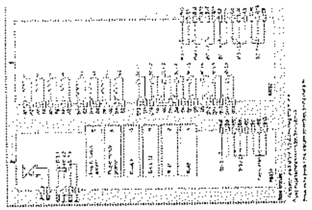

Figure A-6 Standard Variant Type 1

Type 2

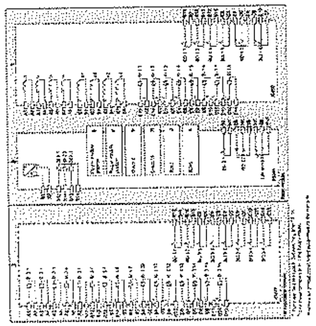

Figure A-7 Standard Variant Type 2

Type 4

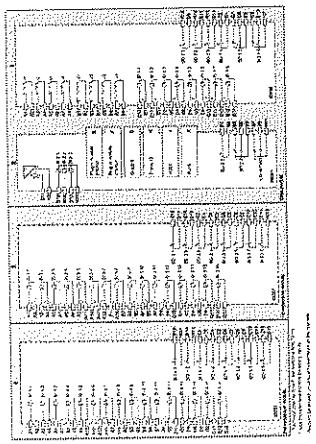

Figure A-8 Standard Variant Type 4

Type 6

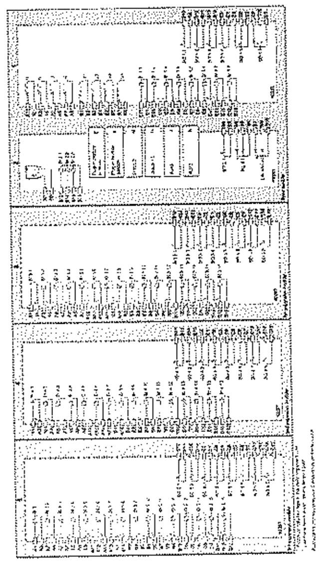

Figure A-9 Standard Variant Type 6

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Type 7

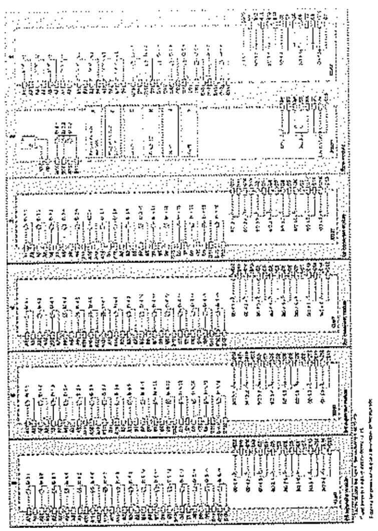


Figure A-10 Standard Variant Type 7

Type 8

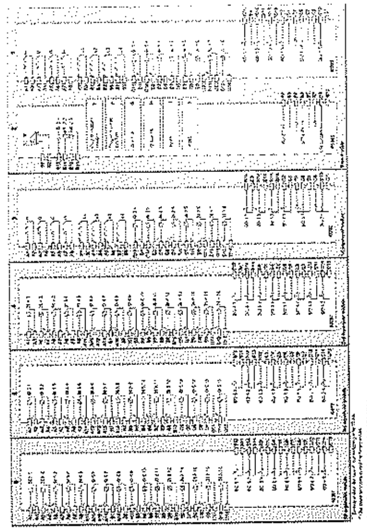
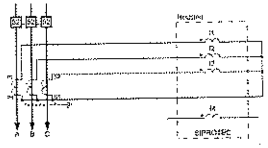


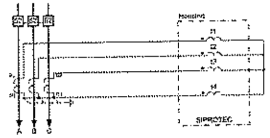
Figure A-11 Standard Variant Type 8

A.6 Connection Examples for Current Transformers



Current transformer 3-phase: connection = 3-phase

Figure A-12 Connection to a 3-Wire Current Transformer (Residual Current to be Calculated)

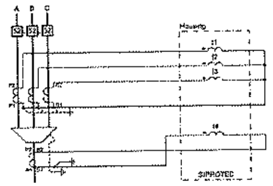


Current transformer 3-phase: connection = 3-phase + IN

Figure A-13 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 relation in the direction of electric current for current input I4 (I_N)!

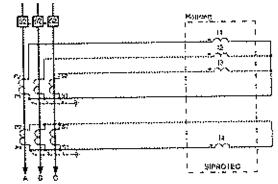


Current transformer 3-phase: connection = 3-phase + IN-separate

Figure A-14 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 relation in the direction of electric current for current input I4 ($I_{N,sep}$)!

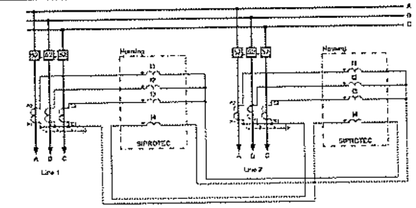


Current transformer 3-phase: connection = 3-phase + IN-separate

Figure A-15 Connection to a 3-Wire Current Transformer and Measured Ground Current from a Complete Holmgreen Connection

NOTE

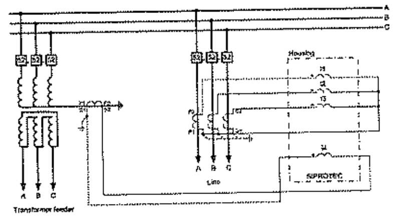
The switchover of current polarity at the 3-phase current transformer causes a relation in the direction of electric current for current input I4 ($I_{N,sep}$)!



Current transformer 3-phase: connection = 3-phase

Current transformer 1-phase: connection = IX

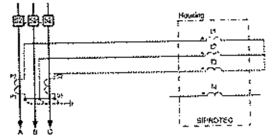
Figure A-16 Connection to a 3-Wire Current Transformer and Measured Residual Current from the Current-Transformer Neutral Point of the Respective Parallel Line (for Parallel-Line Compensation)



Current transformer 3-phase: connection = 3-phase

Current transformer 1-phase: connection = IX

Figure A-17 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-18 Connection to a 2-Wire Current Transformer – for Isolated or Resonant-Grounded Systems Only

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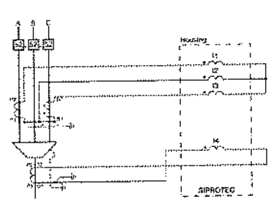
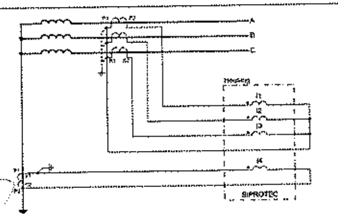


Current transformer 3-phase: connection = 3ph,2prim.CT + IN-sep

Figure A-19 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

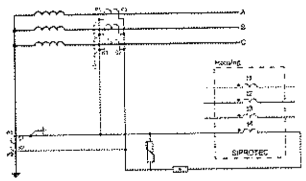
The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 (I_{4sep}).



Current transformer 3-phase: connection = 3-phase

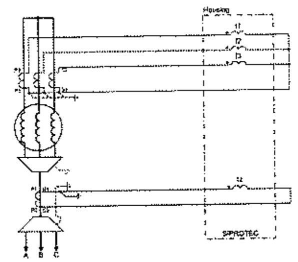
Current transformer 1-phase: connection = Ix

Figure A-20 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

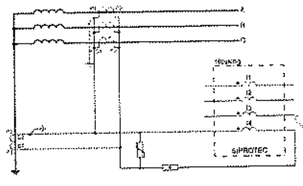
Figure A-21 Current Transformer Connection for High-Impedance Differential Protection (for Example, a Power Transformer, In Preparation)



Current transformer 3-phase: connection = 3-phase

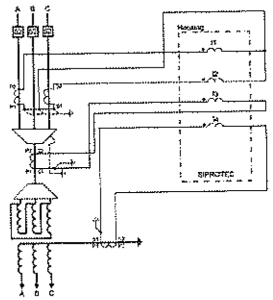
Current transformer 1-phase: connection = Ix

Figure A-22 Connection to a 3-Wire Current Transformer in the Neutral Point of a Generator and Cable-Type Current Transformer for Sensitive Ground-Fault Detection of the Line



Current transformer 1-phase: connection = Ix

Figure A-23 Current Transformer Connection for High-Impedance Differential Protection (Example, a Neutral Transformer)



Current transformer 3-phase: connection = 2ph, 2p. CT + IN-sep

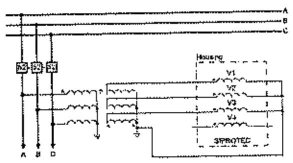
Current transformer 1-phase: connection = Ix

Figure A-24 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

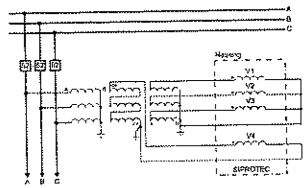
The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I3 (I_{3sep}).

A.7 Connection Examples for Voltage Transformers



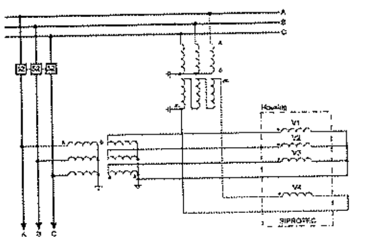
Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Figure A-25 Connection to 3 Star-Connected Voltage Transformers



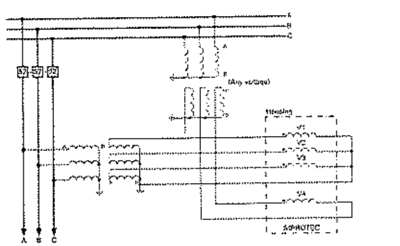
Voltage transformer 3-phase: connection = 3 ph-to-gnd volt. + VN

Figure A-26 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding



Voltage transformer 3-phase: connection = 3 ph-to-gnd volt. + VN

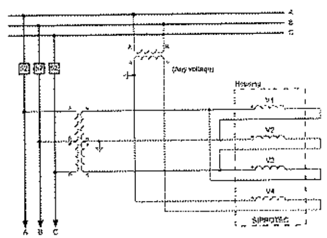
Figure A-27 Connection to 3 Star-Connected Voltage Transformers and to the Broken-Delta Winding of a Separate Voltage Transformer (for example, Busbar)



Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

Figure A-28 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchrocheck Applications)



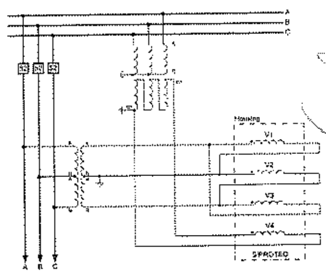
Voltage transformer 3-phase: connection = 3 ph-to-ph voltages

Voltage transformer 1-phase: connection = VAB

Figure A-29 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer

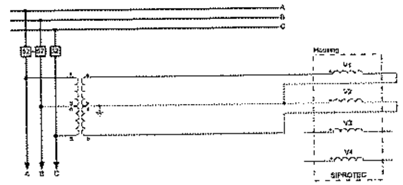
NOTE

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

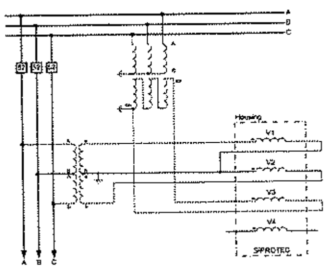
Figure A-30 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



Voltage transformer 3-phase: connection = 2 ph-to-ph voltages

Phase voltages = VAB, VBC

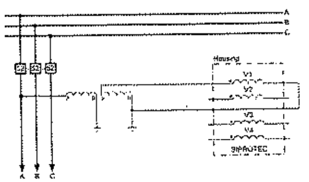
Figure A-31 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)



Voltage transformer 3-phase: connection = 2 ph-to-ph volt. + VN

Phase voltages = VAB, VBC

Figure A-32 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-33 Connection to a 1-Pole-Insulated Voltage Transformer (Phase-to-Ground Voltage)

A.8 Connection Examples for Special Applications

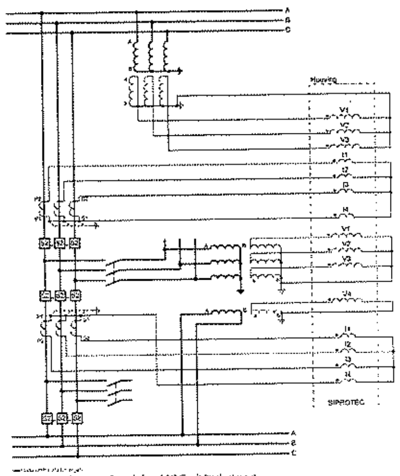


Figure A-34 Connection Example for a 1 1/2 Circuit-Breaker Layout

ВЯРНО С ОРИГИНАЛА

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Glossary

ACD

IEC 61850 data type: Directional protection activation information

ACK

Data transfer acknowledgment

ACT

IEC 61850 data type: Protection activation information

Back-up battery

The backup battery ensures that specified data areas, flags, timers and counters are kept retentive.

Bay Controller

Bay controllers are devices with control and supervision functions and optional protection functions

BCR

IEC 61850 data type: Binary counter reading - dual meter registration

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 length can be chosen from 1 to 4 bytes.

BRCB

See Buffered Report Control Block.

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).

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

See Configured IED Description

Combination Matrix

In an inter device communication (IDC) group, up to 16 SIPROTEC devices suitable for this can communicate with one another. The combination matrix specifies which devices exchange which information.

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.

CRC

Cyclic redundancy check - cyclic redundancy test

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 content 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 parameterization of the device.

DB

See Double Command.

DC

Double Command – See Double Command.

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

See Discovery and Basic Configuration Protocol

DEL

Phase-to-phase measured values in a 3-phase system

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.

DHCP

See Dynamic Host Configuration Protocol

DIGSI

Configuration software for SIPROTEC

Discovery and Basic Configuration Protocol

The DCP protocol is used to detect devices without IP addresses and to assign addresses to these devices.

DM

See Double-Point Indication.

Double Command

Double commands (DC) are process outputs, which the on and off command can give separately on different binary outputs.

Double-point Indication

Double-point indications (DP) 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).

DP

Double-Point Indication – See Double Point Indication.

DPC

IEC 61850 data type: Double Point Control

DPS

IEC 61850 data type: Double-point status

Drag & Drop

Copying, moving and linking function, used in graphical user interfaces. The mouse is used to highlight and hold objects and then move them from one data area to another.

DU

See 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 utilized. The system administrator determines how the IP addresses are to be assigned and specifies the time span over which they are assigned. DHCP is defined in the Internet standards RFC 2131 (03/97) and RFC 2741 (11/97).

EB

See Single Command

Electromagnetic Compatibility

Electromagnetic compatibility (EMC) means that an item of electric 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 system triggers detection of the error on the receive line of the switch.

FEFI

See Far End Fault Indication.

FG

See 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 guaranteed. 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 (GI).

Generic Object-Oriented Substation Event

GOOSE, IEC 61850 protocol for communication between bay units.

GI

See General Interrogation

GIN

Generic Identification Number

GOOSE

See 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.

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 message is sent via 2 separated networks. In contrast to this, in the case of HSR the message 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 messages are relayed in the end device in the case of PRP, a switch function is installed in the HSR node. Thus, the HSR node relays messages 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.

HSR

See High-Availability Seamless Redundancy Protocol

ICD

See IED Capability Description.

IEC

See International Electrotechnical Commission

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.

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.

International Electrotechnical Commission

See IEC

Internet protocol

An Internet protocol (IP) enables the connection of participants which are positioned in different networks.

IP

See Internet protocol

LAN

See Local Area Network

Link Address

The link address indicates the address of a SIPROTEC device.

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.

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.

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ware, and both must support a common transmission protocol (TCP/IP protocols), so that all PCs can exchange data with one another.

Management Information Base

A Management Information Base (MIB) is a database which continuously saves information and statistics concerning each device in a network. 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.

MCB

Circuit Breaker

Metered Value

Metered values are a processing function, used to determine the total number of discrete similar events (counter 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

See Management Information Base

MICS

Model Implementation Conformance Statement

MMS

See Manufacturing Message Specification

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.

NACK

Negative acknowledgment

Navigation Window

The left area of the project window visualizes the names and icons 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

See Optical Switch Module.

Output data/Output direction

Data is sent from the protocol master to the protocol slave.

Output indication

Indications can be information provided by the device on events and states. The events and states are provided via binary outputs, for example, startup of the processor system (event) or fault in a device function (state). These are designated as output indications.

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 message is sent twice, in the case of PRP ("parallel") via 2 separated 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 message is missing, the 2nd message 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 relays 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

In an inter-device communication group, up to 16 SIPROTEC devices suitable for this can communicate with one another. The individually involved devices are referred to as participants.

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.

Phone Book

Participant addresses for the modem connection are saved in this object type.

PICS

See Protocol Implementation Conformance Statement.

PLC

See 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.

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/extension groups (for example, DI, AI, CO, CR), 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.

Protection Communication

Protection Data 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 fault states in distribution networks, taking into account various criteria, such as fault distance, fault direction or fault duration, 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

See 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

Reorganize

The frequent addition and deletion of objects results in memory areas which are no longer used. The reorganization of projects allows these memory areas to be freed up again. The reorganization also leads to I/O addresses being reassigned. This results in all SIPROTEC devices having to be reinitialized.

RSTP

See Rapid Spanning Tree Protocol.

SBO

Select before operate

SC

Single command – See Single Command.

SCD

See Substation Configuration Description

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)

SI

See Single Point Indication.

SI

See System Interface

SICAM PAS

Power Automation System – Substation automation system, modular in design and based on the Substation Controller SICAM SC and the HMI system SICAM WinCC.

SICAM SCC

The HMI system SICAM SCC (serial communications channel) graphically displays the state of your network. SICAM SCC 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.

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.

Single Command

Single commands (SC) are process outputs which visualize 2 process states (for example, On/Off) at an output.

Single-point indication

Single-point indications (SI) 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 5 Variant

This object type represents a variant of an object of the SIPROTEC device type. The device data of this variant can differ from the device data of the original object. However, all variants derived from the original object have its I/O addresses. Therefore they always correspond to the same real SIPROTEC device as the original object. In order to document different working states during parameterization of a SIPROTEC device, you can use objects of the type SIPROTEC variant, for example.

SIPROTEC

The registered trademark SIPROTEC designates the product family of protection devices.

Slave Device

A slave may only exchange data with a master after this 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.

SNMP

See Simple Network Management Protocol.

SNTP

See Simple Network Time Protocol.

SOE

See Sequence of Events.

SP

Single-Point indication → See Single-Point Indication.

SPC

IEC 61850 data type, Single Point Control

SPS

IEC 61850 data type: Single point status

SPS

See Programmable Logic Controller

Substation Configuration Description

A substation configuration description is an IEC 61850-compliant file for data exchange between the system configurator and the IED configurator. The substation configuration description contains information on the network structure of a substation. The substation configuration description contains for example, information on the assignment of the devices to the primary equipment, as well as on the station internal communication.

System Interface

Device interface for linking to the control and protection system via various communication protocols

TC

Tap position command – see Transformer Tap Position Command

TCP

See Transmission Control Protocol.

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, switchgear) and their relation to one another. The Topological View describes the structured layout of the system in hierarchical form.

Transformer-tap indication

The transformer tap indication (TM) is a processing function. The transformer tap changes are recorded and further processed with this indication.

Transformer Tap Position Command

Command which changes the tap position in a transformer.

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 packets.

Tree View

The left area of the project window visualizes the names and icons of all containers of a project in the form of a hierarchical tree structure. This area is referred to as a tree view.

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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

See 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

See Unbuffered Report Control Block

USART

Universal Synchronous/Asynchronous Receiver/Transmitter

User Datagram Protocol (UDP)

UDP is a protocol. The same as TCP, the protocol is based on IP. 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

Value indication

Value indications are single point indications in which a further value is transferred in addition to the actual indication (example: Fault locator: Here the distance to the fault point is also indicated in addition to the fault statement Yes/No.)

Virtual Bay Device

A virtual bay device comprises all communication objects, as well as their properties and states, which a communication user can utilize in the form of services.

Virtual Device

A VD (Virtual Device) includes all communication objects as well as their properties and stages available to communication users in form of services. A VD can be a physical device, a module of a device or a software module.

WYE

DFI (phase-to-ground related measurements of a 3-phase system)

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SIEMENS

SIPROTEC 5
Overcurrent Protection
7SJ82/7SJ85

V7.30 and higher

Manual

CS3000-G5040-C017-7

NOTE
For your own safety, observe the warnings and safety instructions contained in this document, if available.

Disclaimer of Liability

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Edition: 07.2016
Version of the product described: V7.30 and higher

Preface

Purpose of the Manual

This manual describes the protection, automation, control, and supervision functions of the SIPROTEC 5 device functions for distance protection and line differential protection.

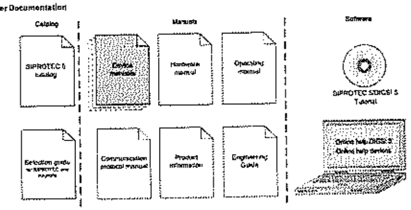
Target Audience

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 www.ul.com

Select Online Certifications Directory and enter E194016 as UL File Number.

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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:

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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.

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.

ВЯРНО С ОРИГИНАЛА

ТИ И ЕК Енерджи ВАРНА VARNA T&N Energy

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Open Source Software

The product contains, among other things, Open Source Software developed by third parties. The Open Source Software used in the 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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ТИ И ЕН ЕНЕРДЖИ ВАРНА VARNA T&N Energy

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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 multiprocessor
- 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)

2 Basic Structure of the Function

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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 this 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.

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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.

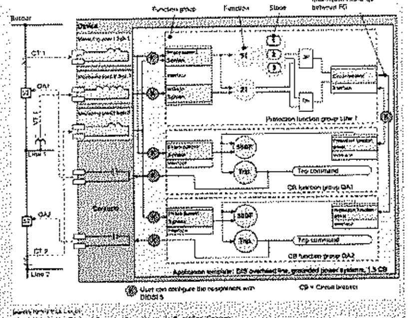

Figure 2-1 Embedding the Functions via Function Groups

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/the transformer. 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, automatic reclosing).

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 feeder-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.

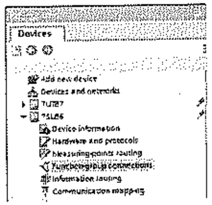

Figure 2-2 Project Tree in DIGSI 5 (Detail)

The window for routing of the measuring points opens in the working area (see the following Figure, does not correspond to the example).

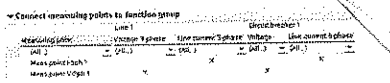

Figure 2-3 Connecting Measuring Points and Function Groups

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).

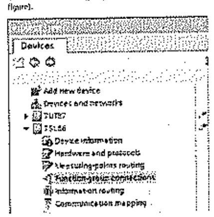

Figure 2-4 Project Tree in DIGSI 5 (Detail)

The window for general routing of the function groups opens in the working area (see following figure).

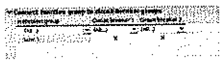

Figure 2-5 Connection of Protection Function Group with Circuit-Breaker Function Group

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. 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).

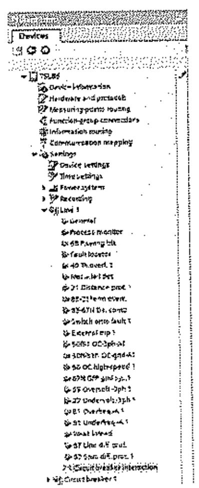

Figure 2-6 Project Tree in DIGSI 5 (Detail)

- 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.

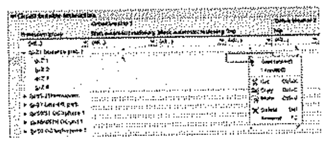

Figure 2-7 Detail Configuration of the Interface Between the Protection Function Group and the Circuit-Breaker Function Group(s)

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 2.3 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 Template

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.

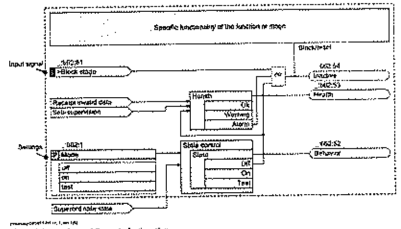

Figure 2-8 General Control of a Function

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 be 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 not 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 this 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 9 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 **Pickup** 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.

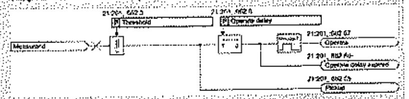

Figure 2-9 Stage of the Overcurrent Protection Function, Phases (without Representation of Stage Control)

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	-

The instance numbers emerge as follows:

- 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

ВЯРНО С
ОРИГИНАЛА

Т и Ен Енерджи
ВАРНА
VARNA
T&N Energy

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 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 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 at 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 pre-defined. You will find information about this at 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 indication 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)).

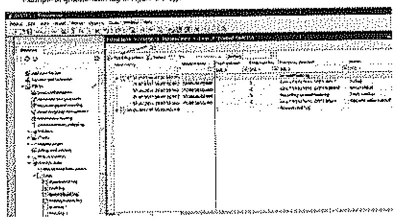

Figure 3-2 DIGSI 5 Display of an Indication List (Example of Ground-Fault Log)

- 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 a)).

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 cause?
- 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 time-out	Select time-out
CB not open	Circuit breaker not open
Communication is interrupted	Communication is interrupted
Topology not stable	Topology not stable
FLO in process	Fault locator in processing
Trigger command active	Trigger command active
Close command active	Close command active

Additional Cause	Meaning
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 to 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

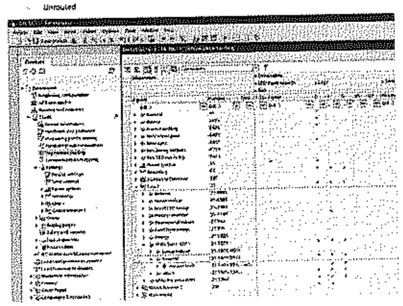

Figure 3-3 Indication Configuration in DIGSI 5 (Example: Ground-Fault Log)

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 headline of the indication list (Figure 3-4 a)).

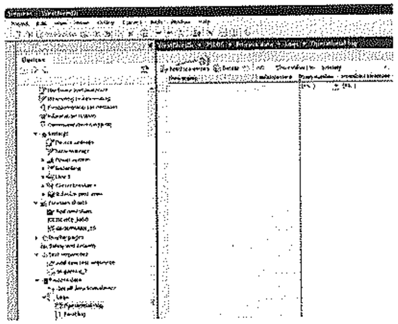

Figure 3-4 Reading the Operational Log with DIGSI 5

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 1000 indications can be recorded in each fault log.

Fault Definition

In general, a fault is started as 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 3.1.8 *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 headline of the indication list.

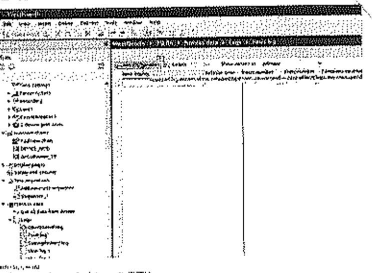

Figure 3-6 Reading the Fault Log with DIGSI 5

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 stored 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 indication:

- **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-diagnosis 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 head line of the indication list (Figure 3-8 a)).

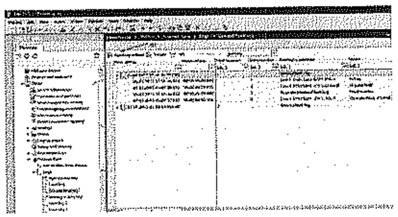

Figure 3-8 Reading the Ground-Fault Log with DIGSI 5

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.

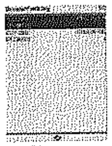

Figure 3-9
Reading the Ground Fault Log on the On Site Operation Panel of the Device

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 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 3-10 a)).

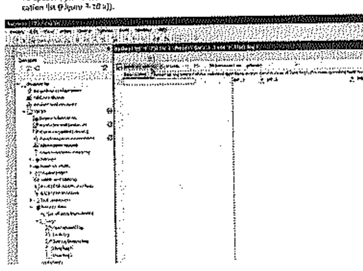

Figure 3-10 Reading the User Defined Log with DIGSI 5

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.

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Figure 3-11
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 it in chapter 3.1.6 *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 columns of the information routing (matrix) of DIGSI 5:

Target → Log → U1 or U2

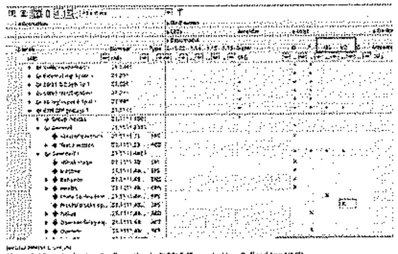

Figure 3-12 Indication Configuration in DIGSI 5 (Example: User-Defined Log U1/2)

3.1.5.6 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 analysis, 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 3-13).

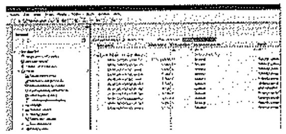

Figure 3-13 Reading the Setting-History Log with DIGSI 5

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 3-14
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.

3.1.5.7 Communication Log

The logging of the respective status such as ongoing faults, test and diagnosis 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.

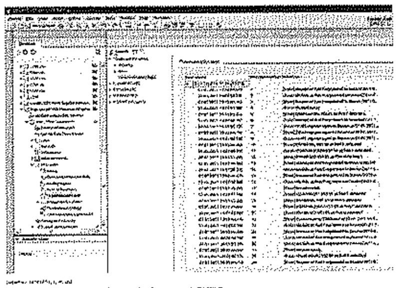

Figure 3-15 Reading the Communication Log with DIGSI 5

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.

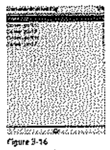

Figure 3-16
Reading the Communication Log on the On-Site Operation Panel of the Device

Deletability

The communication logs of your SIPROTEC 5 device can be deleted. Read details about this in chapter 3.1.6 *Saving and Deleting the Logs*.

Configurability

The communication logs are not freely configurable. The entries are preconfigured.

3.1.5.8 Security Log

Access to areas of the device with restricted access right 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.

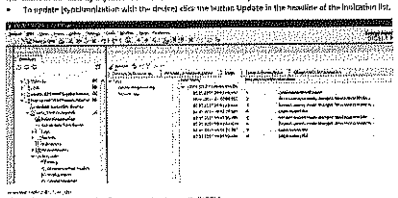

Figure 3-17 Reading the Communication Log with DIGSI 5

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.

3.1.5.9 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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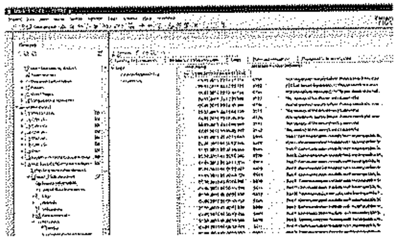

Figure 3-19 Reading the Device-Diagnosis Log with DIGSI 5

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!

3.1.6 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 limitations 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-startup 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 3-21
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.

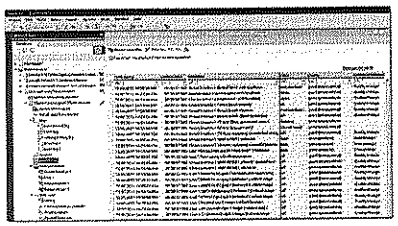

Figure 3-22 Displaying Spontaneous Device Indications in DIGSI 5

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 selection via 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.

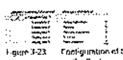

Figure 3-23 Configuration of the Spontaneous Fault Display on the Device

For every display line the following display options can be selected:

Table 3-4 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 3-24
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.

Method 2: Acknowledgement via LED reset

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

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

3.1.9 Stored Indications in the SIPROTEC 5 Device

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

- On-site operation panel
- DIGSI 5

ВЯРНО С ОРИГИНАЛА
Ти и Ен Енерджи * ВАРНА VARNA * T&N Energy

- Binary input
- Protocol of substation automation technology

Configuration of Stored Indications with DIGSI 5

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

You are offered the following options:

Table 3-5 Overview of Routing Options

Routing Options		LEDs	BOs	BIs	Description
H	(active)			X	The signal is routed as active with voltage.
L	(active)			X	The signal is routed as active without voltage.
V	(unlatched)	X	X		The signal is routed as unlatched. Activation and reset of the output (LED, BA) occurs automatically via the binary-signal value.
L	(latched)	X	X		The binary signal is latched when the output (LED) is activated. To reset, a targeted confirmation must occur.
NT	(stored only with tripping)	X			Fault indications are stored when the output (LED) is activated, if the fault is ended with a trip command from the device, the stored state is maintained. In case of dropout of the pickup without trip command from the device (for example, external fault), the state displayed before the fault is restored. Note: Do not confuse the parameter (_:91:139) Fault-display with the setting options with Trip or with pickup. For this routing option, select the setting with trip.
TL	(stored only with tripping)		X		Routing option TL (tripping stored) is only possible for the switching object circuit breaker. The output is saved with protection tripping. The contact remains activated until acknowledged. Control commands are not affected. A control command is pending above the parameterized command period until feedback has been successfully received. Note: You can realize the functionality of the Lockout (ANSI 86) by storing the output relay with the routing option TL.

Acknowledgment of Stored Indications on the On-Site Operation Panel

Acknowledgment via LED Reset

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

Acknowledgment via the operating menu

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

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

Figure 3-25 Reset Functions on the On-Site Operation Panel

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

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

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

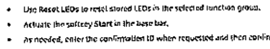

Figure 3-26 Reset Functions on the On-Site Operation Panel (for Example, Line FG)

Acknowledgment of Stored Indications via Binary Inputs

Acknowledgment via entry >LED Reset

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

Acknowledgment of Stored Indications with DIGSI 5

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

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

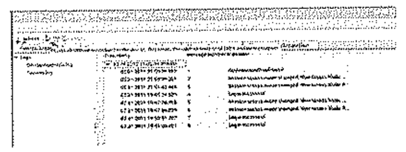

Figure 3-27 LED Reset via DIGSI 5

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

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

Acknowledgment of Stored Indications via Log

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

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

3.1.10 Resetting Stored Indications of the Function Group

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

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

3.1.11 Test Mode and Influence of Indications on Substation Automation Technology

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

3.2 Measured-Value Acquisition

Basic Principle

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

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

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

The following figure shows the basics of dealing with sampled values (SAV) in the measured-value acquisition chain. Figure 3-28 shows to whom the various sampling frequencies are made available. In order to limit the bandwidth of the input signals, a low-pass filter (anti-aliasing filter to maintain the sampling theorem) is installed downstream. After sampling, the current input channels are adjusted. This means the magnitude, phase, as well as the transformer time constant are corrected. The compensation is designed to ensure that the current transformer terminal blocks can be exchanged randomly between the devices.

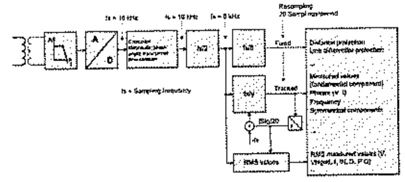

Figure 3-28 Measured-Value Acquisition Chain

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

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

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

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

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

3.3 Processing Quality Attributes

3.3.1 Overview

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

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

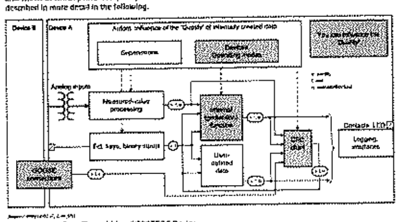

Figure 3-29 Data Flow within a SIPROTEC 5 Device

Supported Quality Attributes

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

- **Validity** using the values *good* or *invalid*
  The **Validity** quality attribute shows if an object transferred via a GOOSE message is received (valid, invalid) or not received (invalid). The *invalid* state can be suppressed in the receiver device by also setting a substitute value for the object that is not received (see Figure 3-30). The substitute value is forwarded to the functions.
  If the device receives one of these values, it is replaced by the *invalid* value and thus processed further as *invalid*.
  If one of the detailed quality attributes (detailQual) has the value *TRUE*, then **Validity** is set to the *invalid* value, unless this was already done at the transmitter end.
- **Test** using the values *TRUE*, *FALSE*
  The **Test** quality attribute indicates to the receiver device that the object received via a GOOSE message was created under test conditions and not operating conditions.

- **OperatorBlocked** using the values *TRUE*, *FALSE*
  The **OperatorBlocked** quality attribute indicates whether an object transferred via GOOSE message originates from a device that is in a *functional logoff* state. When the sending device is switched off, the object is no longer being received and assumes the *invalid* state. However, since the OperatorBlocked quality was previously identified on the receiver device, the object can be treated differently at the receiving end (see chapter 3.3.2 Quality Processing/Affected by the User for Received GOOSE Values). At the receiving end, the object may be treated like a dropped signal.
- **Source** using the values *process*, *substituted*
  The **Source** quality attribute indicates whether the object was updated in the sending device.
  You can find more detailed information in chapter 3.8.2 Acquisition Blocking and Manual Updating.

Influencing Quality by the Operating Modes

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

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

Influencing the Quality through Hardware Supervision

Supervision functions monitor the device hardware (see chapter 9.4 Supervision of the Device Hardware). If the supervision functions identify failures in the data acquisition of the device, all recorded data will receive the quality attribute **Validity** = *invalid*.

Influencing the Quality through Voltage-Transformer Circuit Breakers

If tripping of the voltage transformer circuit breaker is detected (see chapter 9.3.4 Voltage-Transformer Circuit Breaker), all recorded data will receive the quality attribute **Validity** = *invalid*.

Influencing the Quality by the User

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

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

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

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

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

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

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

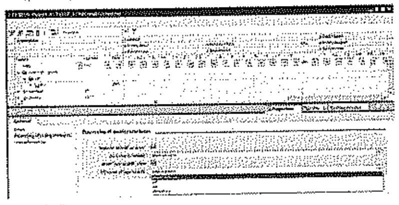

Figure 3-30 Influence Option When Linking an DPC Type Data Object

The setting options work for the device receiving the data.

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

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

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

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

Data Substitute Values

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

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

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

3.3.3 Quality Processing/Affected by the User in CFC Charts

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

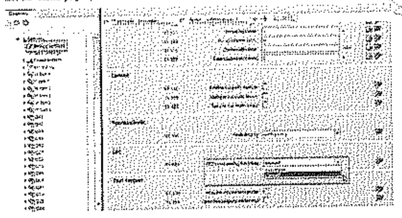

Figure 3-31 Influencing CFC Quality Handling in DIGSI 5

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

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

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

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

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

General Processing

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

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

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

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

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

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

Quality Processing Building Blocks (Condition Processing)

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

Building Blocks	Description		
OR_SPS AND_SPS NEG_SPS	The blocks also process the supported quality attributes according to their logic. The following tables describe the logic using input values in connection with the quality attribute Validity. The input values are 0 or 1, the quality attribute Validity can have the value *good* (=g) or *invalid* (=i). x = placeholder for the input value and quality attribute Validity		
	OR_SPS		
	A (Value, Attribute)	B (Value, Attribute)	Q (Value, Attribute)
	0, i	0, x	0, i
	0, g	0, g	0, g
	1, g	x, x	1, g
	1, i	0, x	1, i
	1, i	1, i	1, i
	The output thus has the logical value 1 with Validity = *good* as soon as at least 1 input has the logical value 1 with Validity = *good*. Otherwise, the inputs are treated according to the OR operation and the INVALID bit is OR-gated for the quality.		
	AND_SPS		
	A (Value, Attribute)	B (Value, Attribute)	Q (Value, Attribute)
	0, g	x, x	0, g
	0, i	1, x	0, i
	1, i	1, x	1, i
	1, g	1, g	1, g
	The output thus has the logical value 0 with Validity = *good* as soon as at least 1 input has the logical value 0 with Validity = *good*. Otherwise, the inputs are treated according to the AND operation and the INVALID bit is OR-gated for the quality.		
	NEG_SPS		
	A (Value, Attribute)	Q (Value, Attribute)	
	0, i	1, i	
	0, g	1, g	
	1, i	0, i	
	1, g	0, g	
SPLIT_SPS SPLIT_DPS SPLIT_XMV	The blocks isolate the data value and quality of a data object. The requirement is that the quality is available from the input end. This is the case if the block is interconnected with CFC input data, or is connected downstream with a quality processing building block (x_SPS). In other cases, the CFC editor does not allow a connection.		
SPLIT_Q	The block performs binary separation of the quality into *good*, *bad* (= *invalid*), *test*, *off* and *OperatorBlocked*. These 5 attributes can then be processed individually in a binary operation. The block must be connected downstream to a SPLIT_(DO) block.		
BUILD_Q	The building block enters a binary value for *good* and *bad* (= *invalid*) in each quality structure. Thus, with this building block the quality attributes *good* and *bad* (= *invalid*) can be set explicitly, for example, as the result of a monitoring logic. All other quality attributes are set to the default state, for instance, Test = *FALSE*. If, for example, the entire CFC chart is in the test state (see Quality Attribute: Test Under General Processing), this default status can again be overwritten on the CFC output side. The building block is normally connected downstream to a BUILD_(DO) building block.		

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

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

EXAMPLE: Switchgear Interlocking via GOOSE

The following conditions apply to the example:

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

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

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

Figure 3-32 CFC Chart with Building Blocks for Quality Processing (Switchgear Interlocking via GOOSE)

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

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

Figure 3-33 provides an overview for processing the quality of data objects within a device-internal function. A function can receive internal data or input data that is routable by the user (binary input signal or double commands). The respective quality attributes supported are evaluated by the function on the input side. The attributes are not passed through the specific algorithm/the specific logic of the function. The output data are supplied with a quality that is specified by the function state and device-operating mode.

NOTE

Take into account that pickup of chatter blocking (see chapter 3.11.1 Signal Filtering and Chatter Blocking for Input Signals) sets the corresponding Validity attribute to invalid.

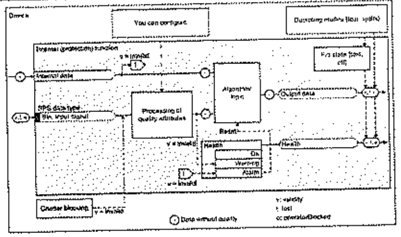

Figure 3-33 Overview for Processing Quality within an Internal Function

Internal Input Data

The quality processing is automatic for internal input data.

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

Routable Binary Input Signals (SPS Data Type)

Figure 3-34 shows the possible sources for connecting a binary input signal. Depending on the source, different quality attributes can be set.

- CFC chart. See description in chapter 3.3.5 Quality Processing/Affected by the User in CFC Charts
- GOOSE connection. See description in chapter 3.3.2 Quality Processing/Affected by the User for Received GOOSE Values
- Device hardware: No quality attributes are set and supported.

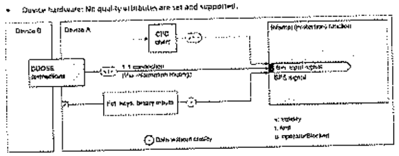

Figure 3-34 Sources for Connecting a Binary Input Signal

For this signal type (SPS), you can influence the processing of the quality, see overview in Figure 3-33. The following figure shows the possible influence on a binary input signal of a protection stage.

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

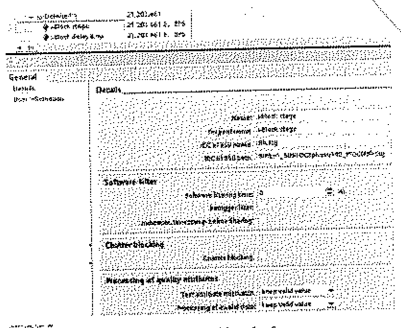

Figure 3-35 Influence Options for a Binary Input Signal (SPS Input Signal)

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

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

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

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

Output Data

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

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

3.4 Fault Recording

3.4.1 Overview of Functions

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

A fault record contains the following information:

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

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

3.4.2 Structure of the Function

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

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

3.4.3 Function Description

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

NOTE

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

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

Sampling Frequency

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

Record Duration

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

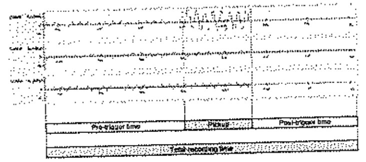

Figure 3-36 Example of a Fault Recording

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

You can set the following values:

- with pickup:
  The fault recording records the complete fault until dropout. The resulting pickup signals of all function groups are taken into account.
- with pickup & AR cyc.:
  In connection with an active automatic reclosing function (internal/external), the fault recordings record the fault including the short and long interruptions (automatic reclosing cycles).
- user-defined:
  With this setting value, you can individually specify the recording criterion for the fault recording in DIGSI 5. Function-specific recording criteria can be realized in this way.

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

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

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

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

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

NOTE

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

Saving the Recording

Not every fault recording that is started actually needs to be saved. With the Storage parameter, you specify whether or not you want to save the fault recording that has started. You can also save only fault data for

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which the pickup of a protection function also caused a tripping. With this setting, faults beyond the self-protection range will not lead to replacing fault recordings that have already been saved.

Configuration of Signals to Be Recorded

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

The operational measured values and the measured values of the fundamental components and symmetrical components (see the Device Manual, chapters 10.3 Operational Measured Values and 10.4 Fundamental and Symmetrical Components) are calculated every 9 cycles (at 50 Hz, this is every 180 ms). However, this can mean that the data are not synchronized with the sampled values of the analog channels. The recording of these measured values can be used to analyze the slowly changing processes.

Numbering and Time Stamping

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

Fault Memory

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

Table 3-6 Maximum Length of all Stored Records

Connection Examples	Sampling 1 kHz	Sampling 2 kHz	Sampling 4 kHz	Sampling 8 kHz
Feeder: 4I, 6 measured values, 20 binary tracks	1365 s	819 s	455 s	241 s
Feeder: 4I, 4V, 20 binary tracks	1125 s	566 s	284 s	142 s
Feeder: 4I, 4V, 6 measured values, 20 binary tracks	890 s	500 s	266 s	137 s
Feeder 1.5 CB: 8I, 8V, 6 measured values, 20 binary tracks	525 s	281 s	145 s	74 s

Input and Output Signals

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

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

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

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

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

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

3.4.4 Application and Setting Notes

Parameter: Fault recording

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

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

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

Parameter: Storage

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

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

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

Parameter: Maximum record time

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

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

Parameter: Pre-trigger time

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

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

Parameter: Post-trigger time

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

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

Parameter: Sampling frequency

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

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

Parameter: Manual record time

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

With the parameter Manual record time, you set the duration of a recording if the fault record is activated dynamically (edge-triggered) via a separately configured input signal >Manual start.

In this case, pre-trigger and post-trigger times do not take effect.

3.4.5 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting
_:2761:116	Control:Manual record time		0.20 s to 20.00 s	0.50 s
_:2761:140	Control:Sampling frequency		• 8 kHz • 4 kHz • 2 kHz • 1 kHz	2 kHz

3.4.6 Information List

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

3.5 Protection Communication

3.5.1 Overview

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

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

3.5.2 Protection-Communication Structure

The following Protection communication functions are visible:

- Topology recognition
- Remote data

The following figure shows the structure of Protection communication:

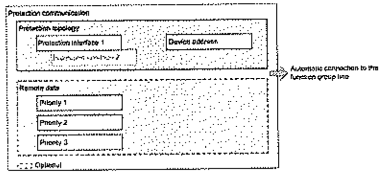

Figure 3-37 Protection-Data Communication Structure

Interface to VI 3-Phase Function Group

Binary signals, measured values, and other data are automatically exchanged between the Protection-data communication and the VI 3-phase protection function group.

Interface to Motor Function Group

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

Remote Data

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

3.5.3 Protection Interface and Protection Topology

3.5.3.1 Overview of Functions

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

A protection topology consists of 2 to 6 devices which communicate via protection interfaces. It can be set up either as a redundant ring or as a chain structure. Within a topology, the protection interfaces can have a different bandwidth. Depending on the bandwidth, a certain amount of binary information and measured values can be transmitted bi-directionally between the devices. The connection with the lowest bandwidth defines this amount (of binary information and measured values).

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

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

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

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

3.5.3.2 Structure of the Function

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

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

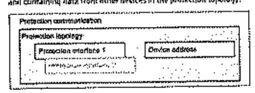

Figure 3-38 Structure of the Protection Interface in a Device

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

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3.5.3.3 Function Description

Topology and Type of Protection Communication

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

Devices connected to one another with protection communication form a protection topology. Refer to Figure 3-39.

The protection communication in a device can be either type 1 or type 2. In the case of devices with differential protection function (75D and 7SL), a protection communication of type 1 is automatically created. Type 2 is created for other devices, and is used for other data transmission. A device can contain only the same types of protection communication. Type 1 and type 2 protection communication do not work together in pairs via a protection function.

Types	Description
Type 1 Application using differential protection	With type 1, the differential protection function is the primary application. This application requires the greatest portion of the bandwidth, so that with type 1 the number of signals additionally available is lower. This becomes noticeable with a 64-kbps protection connection via a G703.1 or X21 interface. If a multiple-end differential-protection application is realized, all protection communications must be of type 1. A maximum of 6 line ends is possible. If the **Differential protection** and **Teleprotection scheme** functions are to operate in parallel in the device, the bit rate must not be less than 512 kbps!
Type 2 Application without using differential protection	Type 2 has a significantly higher amount of information that can be transferred as the differential-protection application is not used here. The transmission of protection data and other data, for example, measured values, is predominant here. Using type 2 protection communication, a maximum of 6 devices can be connected to one another and different device types (for example, 6MD, 7VK, 7SA, and 7SJ) can exchange data.

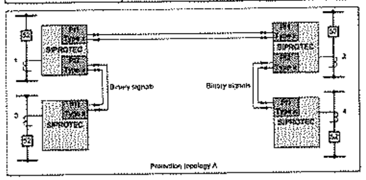

Figure 3-39 Data Exchange between 4 Devices with Protection Communications of Type 1 or Type 2 in a Protection Topology

2-Device Topology: Simple or Redundant Transfer

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

The most frequent application is the point-to-point exchange of data between 2 devices (the protection communication is of type 2), as performed by protection transmission devices.

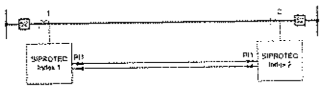

Figure 3-40 Data Exchange for 2 Devices, Each Having Protection Communication

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

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

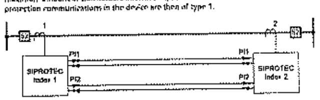

Figure 3-41 Data Exchange for 2 Devices, Each Having 2 Protection Communications/Redundant Transmission Route

Protection-Interface Information Transfer

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

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

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

The number of customer-specific signals, indications, and measured values conform with the remaining bandwidth. The remaining bandwidth is lower than with all other protection functions (type 2) when using a differential protection (type 1). Customer-specific measured values consume more bandwidth than single-point indications.

Communication Media

The communication takes place via direct fiber-optic connections, via communication networks or via 2-wire copper conductors. Siemens recommends a direct fiber optic connection, as this offers the highest transmission rate of 2 Mbps and is immune to failures in the communication route while offering the shortest trans-

mission time. This also enables the transmission of a large amount of additional information for differential protection routes and the remote control of devices at the remote end with DIGSI 5.

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

Table 3-7 to Table 3-8 show examples of communication connections.

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

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

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

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

Table 3-7 Plug-In Modules for Applications with the Protection Interface

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

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

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

Table 3-8 Plug-In Modules USART-AD-1FO and USART-AE-2FO

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

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

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

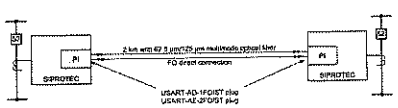

Figure 3-42 Connection over Short Distances, 1.5 km to 2 km via Multimode Optical Fiber

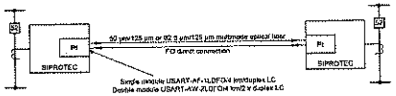

Figure 3-43 Connection over Maximum 4 km via Multimode Optical Fiber

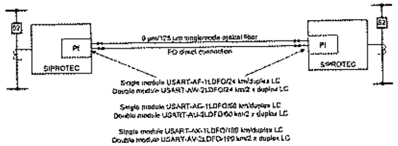

Figure 3-44 Connection via Different Distances via Singlemode Optical Fiber

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

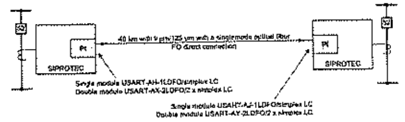

Figure 3-45 Connection via Singlemode Optical Fiber

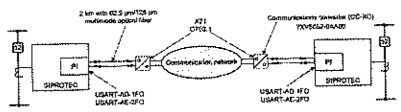

Figure 3-46 Connection via Communication Network with a G703.1 Interface

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

You can find more detailed information in Table 3-9.

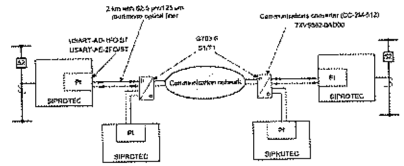

Figure 3-47 Connection via Communication Network with a G703.6 Interface

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

Make the setting for the bit rate with KU 2M 512 with 512 kbps in accordance with Table 3-9 with the parameter `Connection via`.

360

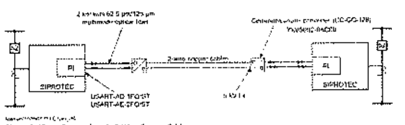

Figure 3-48 Connection via 2 Wire Copper Cables

The connection to a communication converter with an integrated 5 kV isolation voltage is established with 128 kbps (KU KU 128 setting in accordance with Table 3-9). A 20 kV isolation of the 2 wire connection is possible via an external 7XR9516 isolating transformer.

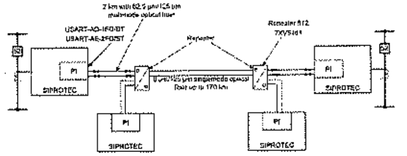

Figure 3-49 Direct Fiber-Optic Connection via an External Repeater

The repeater offers an interface for connecting an additional protection interface. The connection to a repeater is established with 512 kbps (repeater 512 setting in accordance with Table 3-9).

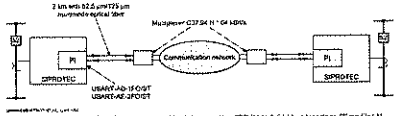

Figure 3-50 Direct Optical Connection to a Multiplexer with a C37.94 N * 64 kbps Interface (Time Slot N = 1; 2 or 8)

NOTE

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

Supervision of the Communication

The communication is continuously monitored by the devices.

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

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

Time Synchronization via the Protection Interface

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

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

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

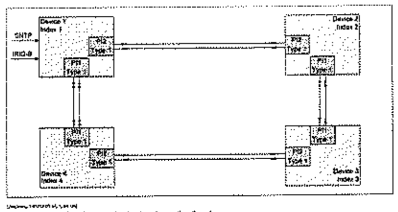

Figure 3-51 Time Synchronization in a Protection Topology

Figure 3-51 shows how device 1 with index 1 is synchronized with the devices 2, 3, and 4 via the protection interface. Device 1 is synchronized externally from 2 sources (IRIG-B and SNTP via Ethernet).

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

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

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

NOTE

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

Synchronization via GPS Second Pulse

Millisecond-accurate synchronization of the devices (1 * 10E-06 s), connected via protection interfaces, can take place via a high-precision GPS second pulse at the time-synchronous port G for special differential protection applications or synchrophasor measuring devices. As a result, the transmission time of the communication route can be measured and displayed separately in the forward and reverse directions. This ensures that the maximum responsivity can be obtained during differential protection, even if transmission times are unbalanced in the communication networks. Different transmission times are insignificant for the transmission of protection data with a protection communication of type 2.

Log Off the Device

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

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

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

NOTE

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

3.5.3.4 Initialization and Configuration of the Protection Interface in DIGSI 5

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

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

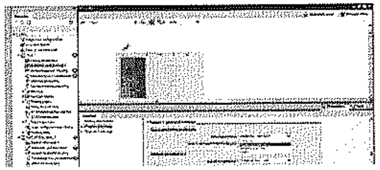

Figure 3-52 Selection of the Communication Protocol

- Then select the **Select constellation** text box to select the number of devices (see next figure).

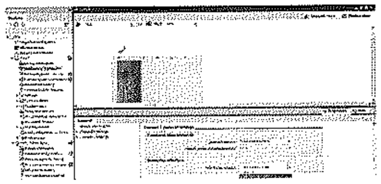

Figure 3-53 Selecting the Constellation

NOTE

You have the option of changing the number of devices (for example 2 protection communication devices) depending on the product code any way you like via the **Select constellation** text box.

If you change the number of devices via the Select constellation text box, all activated constellation settings are lost.

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

- Select the desired communication module in the rear view of the device.
- Select the module from the catalog and drag it to a channel. Thus is the channel configured with a module. DIGSI 5 indicates whether the module can be used for protection communication under **Device Information**.
- Use the **Communication protocols** text box to select the protection interface. A text box entitled **Protection interface** will then appear (see *Figure 3-52*).
- Then use the **Select constellation** text box to select the number of devices (for example 2 devices protection com.) (see *Figure 3-53*).

3.5.3.5 Device-Combination Settings

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

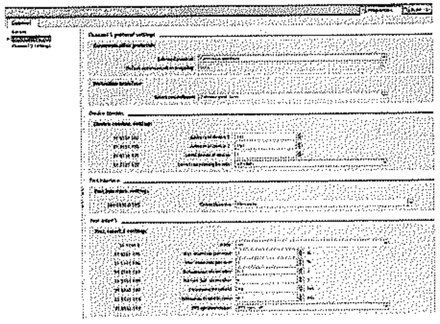

Figure 3-54 Protection Interface Initialization and Configuration

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

Setting Device-Combination Settings

- Default setting (_:5131:102) `Address of device 1 = 101`
- Default setting (_:5131:103) `Address of device 2 = 102`
- Default setting (_:5131:104) `Address of device 3 = 103`

- Default setting (_:5131:105) `Address of device 4 = 104`
- Default setting (_:5131:106) `Address of device 5 = 105`
- Default setting (_:5131:107) `Address of device 6 = 106`

The parameters `Address of device 1` to `Address of device 6` can be used to give an address to each device. Set a unique and unambiguous address for each device.

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

With the `Local device is device` parameter, you set the index (number) of your device in the topology. A maximum of 6 devices can be present in one topology.

APPLICATION EXAMPLE

You have a topology with 2 devices.
For example, in DIGSI 5, select the parameter setting `Address of device 1` with the parameter value `101` for device 1 and the parameter setting `Address of device 2` with the parameter value `102` for device 2.
Then, use the `Local device is device` parameter to set the index of the local device.

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

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

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

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

- `128 kBit/s`
- `512 kBit/s`
- `2048 kBit/s`

NOTE

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

3.5.3.6 Selecting the Connection

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

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

Table 3-9 Means of Communication

Means of Communication	See	Setting Value	Bit Rate
Fiber-optic direct connection	Figure 3-42 to Figure 3-44	`fiber optic`	2 MBit/s
CC-XG-512 communication converter	Figure 3-46	`CCXG 512 kBit/s`	512 kBit/s
CC-XG-128 communication converter	Figure 3-46	`CCXG 128 kBit/s`	128 kBit/s
CC-XG 64 communication converter	Figure 3-46	`CCXG 64 kBit/s`	64 kBit/s

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Means of Communication	See	Setting Value	Bit Rate
Repeater 512 communication converter	Figure 3-48	repeater 512 kBit/s	512 kBit/s
CC-CC-128 Communication converter	Figure 3-48	CCC 128 kBit/s	128 kBit/s
CC-2M-512 Communication converter	Figure 3-47	CC2M 512 kBit/s	512 kBit/s
Multiplexer with C37.94 interface	Figure 3-50	C37.94 1 * 64 kBit/s C37.94 2 * 64 kBit/s C37.94 8 * 64 kBit/s	64 kBit/s 128 kBit/s 512 kBit/s
Other (freely adjustable bit rates for a direct connection for special applications)		64 kBit/s 128 kBit/s 512 kBit/s 2048 kBit/s	64 kBit/s 128 kBit/s 512 kBit/s 2048 kBit/s

NOTE

Keep in mind that the Teleprotection schemes require a minimum bandwidth for communication via a protection interface.
If the Line differential protection function is available in the device, the bit rate must not be less than 512 kBit/s.
The minimum bit rate of 512 kBit/s is important for the Teleprotection with distance protection and Teleprotection with ground-fault protection functions.

3.5.3.7 Setting Notes for the Protection Interface

Parameter: Max. Error Rate/h

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

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

Parameter: Max. Error Rate/min

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

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

Parameter: Disturbance Alarm After

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

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

Parameter: Transm. Fail. Alarm After

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

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

NOTE

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

Parameter: Delay time threshold

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

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

Parameter: Difference Tx and Rx time

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

The Difference Tx and Rx time parameter can be used to set a maximum time-delay difference between the send and receive paths.
Set this value to 0 for a direct fiber-optic connection. A higher value is necessary for transmission via communication networks. Reference value: 0.1 ms (recommended setting value).

NOTE

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

NOTE

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

Parameter: PPS Synchronization

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

If the SIPROTEC device operates with PPS synchronization (PPS: pulse per second), use the PPS synchronization parameter to define how the protection is activated after restoration of the communication connection (basic state or after transmission fault).
Refer to Figure 3-55.

NOTE

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

The PPS synchronization parameter offers 3 different setting options:

Parameter Value	Description
telegr. and PPS	With this setting, the differential protection is only enabled upon renewed establishment of the connection, if the communication section is synchronized via PPS or if symmetrical time delays are signaled by an external operation (binary input). This results in synchronization with the telegram measurement supported by the PPS measurement.
telegr. or PPS	In this setting, the differential protection is enabled immediately upon renewed establishment of connection (data telegrams are received). The conventional method is used up to synchronization. This results in synchronization with the telegram measurement supported by the PPS measurement.

Parameter Value	Description
PPS sync. off	This setting means that no synchronization is performed via PPS at the protection interface. This is typically the case if no time-delay differences are expected. The synchronization only takes place with the telegram measurement.

NOTE

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

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

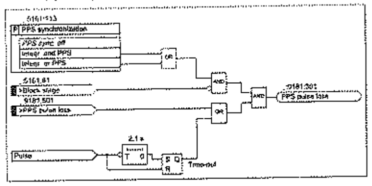

Figure 3-55 Setting the PPS Synchronization

The binary input >PPS pulse loss can be used to signal an externally detected failure in the PPS signal (for example, error message from the receiver). Setting this binary input also leads to the indication PPS pulse loss.
If you are using a second pulse from a GPS receiver, you must ensure that a loss of reception or reception disturbances do not generate a second pulse. The GPS receivers recommended by Siemens are set by default so that a loss of reception or reception disturbances do not generate a second pulse. In the event of problems, check the setting value for the second pulse.
Siemens recommends the **Meinberg 164 GPS** receiver. Check the default setting for the second pulse using the **GPSMON32** program. The program is available in the SIPROTEC download area. You can find the setting value under Outputs → Enable Flags. The second pulse must be set to the value 1S Sync.

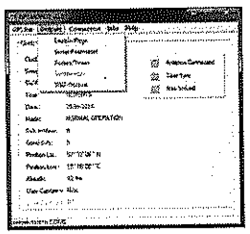

Figure 3-56 Checking the Setting Value for the 2nd Pulse Using the GPSMON32 Program, Step 1

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

3.5.3.8 Routing Information in DIGSI 5

Protection communications of the same type form a topology.
For more information on this, see chapter 3.5.1.1 Function Description.
A data bar is exchanged between the devices of a topology connected via protection communication. This can be written into or read from by the devices. This can be used for exchanging various signals between the devices. In this case, each signal demands a certain number of data fields.

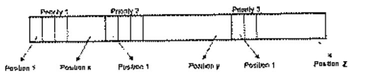

Figure 3-58 Data Bar Exchanged Between Devices

The data bar is divided into 3 priorities, which also have different transmission rates and data volumes. The following basic principle applies for all messages: Only pure data contents are transmitted. The quality (for example, Test Fd) is not automatically transmitted as well. If you want to transmit the quality as well (for

example, for further processing of GOOSE messages), the quality must be transmitted separately (for example, by using CFC). If a signal that has a test flag is transmitted (because its function is in test mode, for example), all signals are provided with a test flag on the receiving side. If the connection is broken, all received signals are flagged with the quality Invalid. If desired, the value can also be set to a secure state after a selectable dropout time, or the last value received can be retained (Hold setting). This can be configured separately for each received signal (see Table 3-13).

NOTE

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

Indications that are transferred data fields of priority 1 are sent with every telegram. They are preferably used for the transmission of rapid signals, for example, release for circuit-breaker intertripping. A strictly deterministic, rapid transmission is required there.
Signals of priority 2 are transmitted with at least every 2nd telegram. For bit rates ≥ 256 kBit/s, there are no differences between priority 1 and priority 2.
Priority 3 information is transmitted at least every 100 ms. This priority is used for transmission of measured and metered values. Complex values must be routed separately as the real and the imaginary part for transmission. Measured value thresholds that lead to an updating of a measured value are set centrally as a property of the measured value. These measured-value thresholds apply with the corresponding reporting, for example, also for the transfer via IEC 61850 to a substation automation technology.
Indications which are written in a data area x under a priority on the data bar must be routed to an indication of the same type in the device reading this information. Otherwise, they are processed incorrectly on the receiving side. The data bar is organized in terms of bits. For information on the bit requirement of each signal type, refer to Table 3-12.
Table 3-10 and Table 3-11 show the number of data areas in the data bar in relation to the available baud rate.

NOTE

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

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

Table 3-10 Available Bits - Minimum Constellation Baud Rate 64/128 kBit/s

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

Table 3-11 Available Bits - Minimum Constellation Baud Rate 512/2048 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	48 Bits	128 Bits	384 Bits
Type 2	96 Bits	256 Bits	1024 Bits

Table 3-12 Requirement in Bits

Signal Type	Size in Bits
SP (single-point indication)	1 Bit
DP (double-point indication)	2 Bits
BI (metered values)	32 Bits

Signal Type	Size in Bits
MW (measured values)[1]	32 Bits
ACT	4 Bits

Table 3-13 Possible Dropout Values

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

NOTE

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

EXAMPLE

2 devices are connected via a 64-kBit/s channel. This is a type 1 topology. 8 bits are freely available for priority 1. Now, for example, 4 SPS and 2 DPS can be routed:
4 × 1 Bit + 2 × 2 Bits = 8 Bits

NOTE

Measured values are transmitted as primary values.

EXAMPLE

For the rated current display in the receiving device
When I_{prim} = 1000 A in the transmitting device and I_{prim} = 200 A, the number 200 is displayed in the receiving device.

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

The transmission is organized in the form of a data bar which is continuously exchanged between the devices. For this, see Figure 3-58.
A device indication or measured value is allocated to a definite data area of the bar.
Figure 3-59 to Figure 3-62 show the routing for a communication topology of connection interface type 1.
To transmit signals to other devices, these signals must be routed in the communication matrix under Transmit. Binary inputs 1 and 2 are single-point indications (SPS) and are routed to position 1 and position 2 of the transmission with the highest priority (priority 1). For 64 kBit/s, for example, only 8 of these data areas are available for type 1. They are exchanged between the transmission routes with each telegram. Signals 3 and 4 are double-point indications (DPS), for example, a switch position that is transmitted by a device 1. A double-point indication occupies 2 positions on the data bar. In addition, a measured and metered value are connected via priority 3.
As a measured or metered value uses 32 bits, value 2 starts at position 33. DIGSI 5 indicates the next available position.

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

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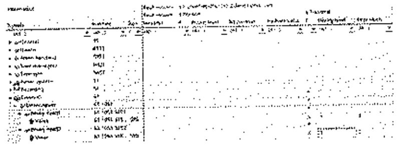


Figure 3-59 Routing of Single-Point Indications to the Protection Interface in Device 1

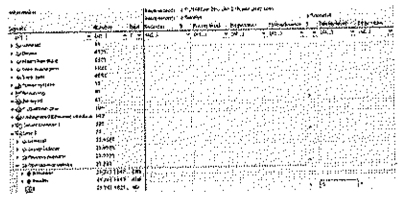


Figure 3-60 Routing of Measured Values to the Protection Interface in Device 1

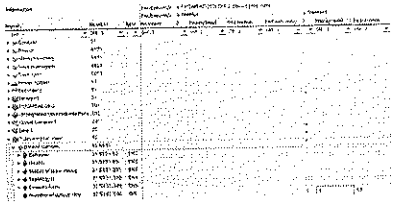


Figure 3-61 Routing of Metered Values to the Protection Interface in Device 1

This device also receives information (in the matrix under **Receive**). This must have been routed as a target for other devices (see next figure). The binary outputs 1 and 2 in device 1 receive their information via the protection interface. This is priority 1 information, which has been routed in another device to position 3 and 4 of the data bar. The secure state is defined in the **Fallback value** column. If the data connection fails, the single-point indication is reset to *coming* or *going* or its value is retained (*hold*). For data of the various priorities, you can also set a dropout time after which the resetting (see Figure 3-67) to the fallback value occurs, in order to retain the original state for a short time in the event of brief interruptions. These 3 dropout times apply for all data of one transmission priority and are set as parameters.

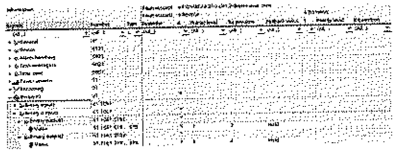


Figure 3-62 Routing of Single-Point Indications (Receive) to the Protection Interface in Device 1

The following figure shows the routing in the 2nd device. Binary inputs 1 and 2 are routed with priority 1 to positions 3 and 4 there. In device 1, positions 1 and 2 are already occupied (see Figure 3-59). If you also route the signals to positions 1 and 2, the signals of the devices are then connected to the corresponding position with a logical OR operation. If measured and metered values are routed in the same data areas, this results in implausible values for the receivers that read the data. As a user, you are therefore responsible for the correct routing.

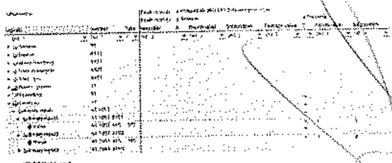


Figure 3-63 Routing of Single-Point Indications to be Sent to the Protection Interface in Device 2

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

Hold is used to retain the state.

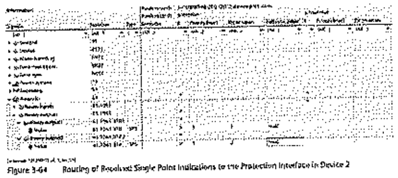


Figure 3-64 Routing of Received Single-Point Indications to the Protection Interface in Device 2

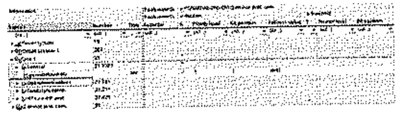


Figure 3-65 Routing of Received Measured Values to the Protection Interface in Device 2

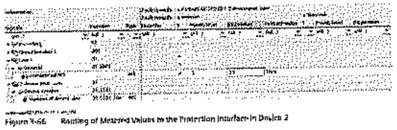


Figure 3-66 Routing of Metered Values to the Protection Interface in Device 2

3.5.3.9 Diagnostic Measured Values of the Protection Interface

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

- Address of the device in the constellation
- Circuit-breaker switch position (open/closed/undefined) (only for protection interfaces of type 1)
- Availability of protection-interface communication within the last minute, as percentage
  Availability of protection-interface communication within the last hour, as percentage
- Time delay in the send and receive direction of the telegrams between local and neighboring device

You can find this diagnostic data in DIGSI under the following menu structure (see Figure 3-67):

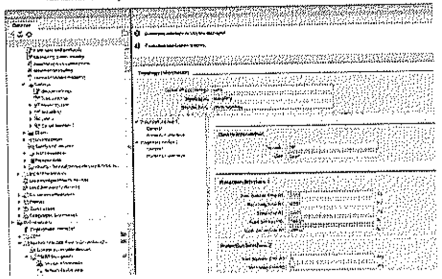


Figure 3-67 Protection Interface Channel Diagnostic Data - Device Address

NOTE

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

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

Output Signals of the Protection Interface

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

Indication	Description
(_:5161:301) *Status of lay. 1 and 2*	The output signal gives you information about the state of communication layers 1 and 2 (1: Physical Layer, 2: Data Link Layer). The following indications values are possible: • *Initialized* The protection interface is not connected and is in the initial state. • *Protection interface connected* The protection interface is connected to the protection interface of a device. • *Protection interface disturbance* The protection interface has not received any valid telegrams for the time set in parameter (_:5161:107) Disturbance alarm after. • *Protection interface failure* The protection interface has not received any valid telegrams for the time set in parameter (_:5161:108) Transm. fail. alarm after. • *not present* The protection interface has not been assigned to a communication channel.

Indication	Description
(_:5161:302) *Status of lay. 3 and 4*	The output signal gives you information about the state of communication layers 3 and 4 (3: Network Layer, 4: Transport Layer). The following indications values are possible: • *no error* The protection interface is operating correctly. • *Software version incompatible* The firmware versions of the connected devices are incompatible. Update the firmware. • *System mirroring* The protection interface is receiving its own data. Check the wiring. • *Dev. add. incorrect* The device address of the partner device is incorrect. Check the settings for parameters Address of device 1 to Address of device n (_:5131:102 and following). • *Constell. incorrect* The constellation settings of the devices are different. Check that the setting for the parameter Select constellation is identical in all devices. • *Const. param. incorrect* Check that the same setting has been made for parameter (_:5131:122) Lowest appearing bit rate in all devices. • *Diff. Param. Error* The line differential protection settings for the connected devices are incompatible. Check whether both devices are set to operate with or without line differential protection. The rated value of the line (parameter (_:9001:101) Rated current and (_:9001:102) Rated voltage) must have the identical setting at both ends of the line. If a transformer is installed in the line, both parameters must be set such that the rated apparent power is the same at both ends of the line (parameter (_:9001:103) Rated apparent power).

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

Binary Output Signal	Description
(_:5161:303) *Connection broken*	Signal *Connection broken* indicates that during a parameterized time (parameter (_:5161:107) Disturbance alarm after) faulty or missing telegrams were continuously received. If the 'Connection interrupted' indication occurs, the affected protection interface link will be terminated. This can cause the blocking of an active differential protection or a ring topology can change to a chain topology.
(_:5161:316) *Error rate / min exc.*	Signal *Error rate / min exc.* indicates that the set maximum error rate per minute (Parameter (_:5161:106) Max. error rate per min) has been exceeded.
(_:5161:317) *Error rate / hour exc.*	Signal *Error rate / hour exc.* indicates that the set maximum error rate per hour (Parameter (_:5161:105) Max. error rate per hour) has been exceeded.
(_:5161:318) *Time delay exceeded*	Signal *Time delay exceeded* indicates that the threshold value for the set signal-transit time (Parameter (_:5161:109) Delay time threshold) has been exceeded.
(_:5161:319) *Time delay different*	Signal *Time delay different* indicates that the threshold value for asymmetrical transit times has been exceeded. The setting value results from the setting value of the parameter (_:5161:110) Difference Tx and Rx time
(_:5161:320) *Time delay jump*	Signal *Time delay jump* indicates that the data transit times changed abruptly. This is caused by switching the communication path in the communication network.

Binary Output Signal	Description
(_:5161:322) PI synchronized	Signal PI synchronized indicates that the protection interface connection is synchronized with the opposite end.
(_:5161:340) Telegram lost	Signal Telegram lost indicates that an expected telegram has failed to arrive or a faulty telegram has been received. If you would like to allocate the communication failures or faults to other events, route the signal Telegram lost temporarily into the operational log. Such events can be switching operations in the primary system or operations on the components of the communication network. Note: If the signal is constantly routed, the operational log can overflow. Siemens recommends routing the signal only for clarification of faults.

Measured Values of the Protection Interface

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

Measured Value	Description
(_:5161:308) Tx tel/h	Telegrams sent during the last hour
(_:5161:309) Rx tel/h	Telegrams received during the last hour
(_:5161:310) Tx tel/min	Telegrams sent during the last minute
(_:5161:311) Rx tel/min	Telegrams received during the last minute
(_:5161:312) Tx err/h	Transmission failure rate during the last hour
(_:5161:313) Rx err/h	Reception failure rate during the last hour
(_:5161:314) Tx err/min	Transmission failure rate during the last minute
(_:5161:315) Rx err/min	Reception failure rate during the last minute
(_:5161:325) Aver.Δt	Mean signal-transit time (average value of the transit time in transmission and reception direction divided by 2, without GPS synchronization)
(_:5161:326) Rec. Δt	Signal transit time in reception direction (with GPS synchronization)
(_:5161:327) Sen. Δt	Signal-transit time in transmission direction (with GPS synchronization)
(_:5161:334) Miss.tel/min	Number of telegram failures within the last minute
(_:5161:335) Miss.tel/h	Number of telegram failures within the last hour
(_:5161:336) Miss.tel/d	Number of telegram failures within the last day
(_:5161:337) Miss.tel/w	Number of telegram failures within the last week
(_:5161:338) M.loss/d	Longest lasting telegram failure within the last day
(_:5161:339) M.loss/w	Longest lasting telegram failures within the last week

NOTE

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

3.5.3.10 Tunneling with DIGSI 5 via Protection Interface

Configuration of the Subnetworks

You can use a PC to access other devices within the constellation via the protection links. DIGSI 5 communication then operates exclusively via the connections and the protection-data communication is turned off. In this way, you operate the remote devices from the local device via DIGSI 5.

Remote control with DIGSI 5 is only possible if you are online with the local device and connected there with the integrated Ethernet interface RJ45

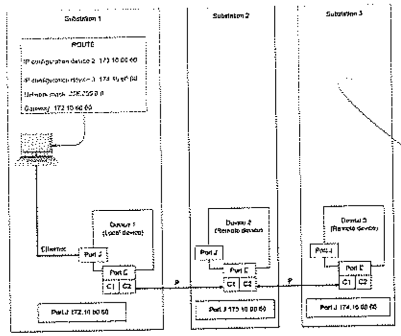
NOTE

All remote devices need an IP configuration for port J (integrated Ethernet interface) in all cases. The IP addresses of slots J of a protection topology must be in different subnetworks.

NOTE

If reparameterization requires a restart of the remote device, then the corresponding route is not available until after approx. 2 min. following a complete restart.

The following figure shows a configuration with 3 devices as an example.



C1 Channel 1
C2 Channel 2
P Protection connection

Figure 3-68 Sample Configuration of a Remote Control with 3 Devices

Tunneling with DIGSI 5 via Protection Interface: Procedure

If you want to perform tunneling (remote control)[1] via DIGSI 5, proceed as follows:

- You make a connection between DIGSI 5 and the device through the Ethernet RJ45.
- Open the device concerned in Online access.
- Go to Test suite/Protection topology.
- Open Protection topology. In the next window, press the button at top left (see arrow in the following figure). The dialog for deactivating the protection communication then opens.
  If you confirm the query, protection communication is interrupted and the communication channels are used exclusively for DIGSI 5. Note that the protection functions that use protection data communications (e.g. differential protection) are deactivated and no remote data can be updated in the constellation. Then, the remote signals fall back to the secure state the user has defined earlier.

[1] This function is not yet implemented and will first be activated with a later firmware version

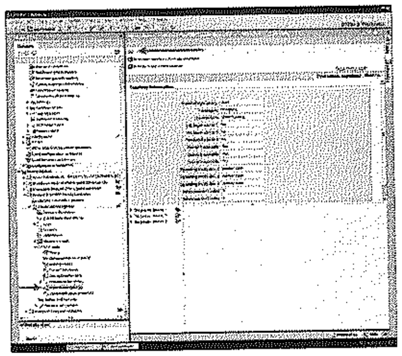


Figure 3-69 Tunneling with DIGSI 5

NOTE

The protection communication remains interrupted until either the user reactivates it manually, or a maximum deactivation duration of 12 hours has been exceeded. After this, the connection reactivates itself. This ensures that the protection communication and protection function working with it are reactivated.

NOTE

Ensure that DIGSI 5 is connected via Ethernet to RJ45 of the local device. The local device must be configured with valid IP addresses.

Figure 3-70 to Figure 3-71 show the steps for the deactivation of protection communication.

In the next step, a window appears in DIGSI 5 containing the instructions for deactivating the protection data communication (see next figure).

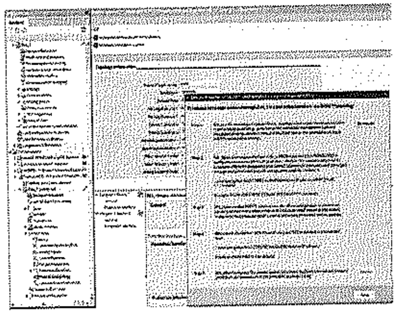


Figure 3-70 Steps for the Deactivation of Protection Communication

In order to be able to deactivate the protection-data communication, you must enter your confirmation ID if a security query is activated (see next figure). The default confirmation ID is 222222.

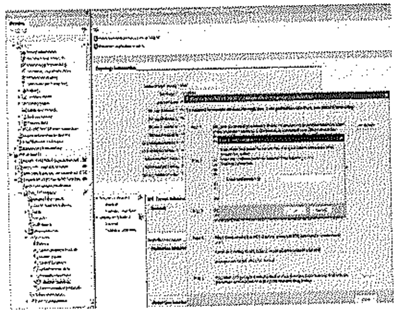


Figure 3-71 Entering the Confirmation ID for the Deactivation of Protection Communication

- Under Start —> Run in Windows, open an input window by entering CMD.
  Use the DOS box to enter a command line to set a route (see next figure). This is the prerequisite that DIGSI 5 can be routed further via the protection interface.

Figure 3-72 Setting of the Route in the DOS Box

NOTE

To set the route, you must have administrator rights for the DIGSI PC.

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- The following routing command is necessary to connect from device 1 to device 2 in the example shown (see Figure 3-68).
  Route add 173.16.60.60 Mask 255.255.0.0 172.16.60.60
  Route <Command> Destination (= Device 2) Mask (Routing Device) Local Device

  Remote devices must be available in different subnetworks and provided with unique IP addresses. For this, RJ45 of the relevant devices must already be configured so that these devices can now be accessed remotely.
- Now, select your DIGSI 5 project for substation 2 and connect this to the device. Although you are physically connected to the local device, this device now establishes a connection with the remote device. You can now fully operate the remote device with DIGSI 5.
  After completing the process, the protection communication must be reactivated. For this, end the connection with the remote device in DIGSI 5 at the local device for the protection interface.
  If this communication is not terminated properly, the protection-data communication then switches on again automatically after about 12 hours.
- Delete the route again by entering the following in the DOS box:
  – Route Delete 173.16.60.60
- If you wish to access device 3 via the protection interface, proceed in the same way. In this case, the DIGSI 5 communication is routed to device 3 via device 2 and you are connected from device 1 to device 3.
- To establish a connection with device 3, the following route is necessary:
  - Route add 174.16.60.60 Mask 255.255.0.0 172.16.60.60

NOTE

If there is no connection between the local device and DIGSI 5 for longer than an hour, the connection automatically reverts to protection communication.

3.5.3.11 Diagnostic Data for the Protection Interface

Diagnostic Data of the Channel in DIGSI 5

Different diagnostic data can be read with DIGSI 5.

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

NOTE

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

The following table describes the displays.

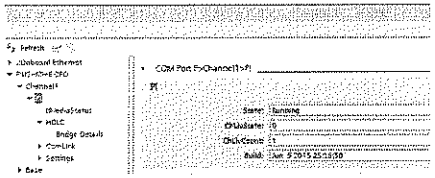

Figure 3-73 Diagnostic Data of a Channel Configured with the Protection Interface

Table 3-14 Description of the Diagnostic Data under Protection Interface

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

Diagnostic Data of the Protection-Interface Log in DIGSI 5

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

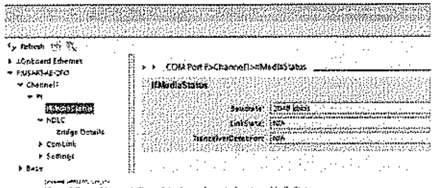

Figure 3-74 Diagnostic Data of the Protection Interface Log - Media Status

Table 3-15 Description of Diagnostic Data under Media Status

Protection Interfaces - Log Type	Name	Values	Description - Media Status Interface (in Direction of Outside Interface)
Media Status	Baud rate	64 kBit/s; 128 kBit/s; 512 kBit/s; 2048 kBit/s; 30 MBit/s; <unknown>	HDLC baud rate FO: 64 kBit/s to 2048 kBit/s for 820-nm USART modules LDFO: 30 MBit/s for 1300/1550 nm long distance modules Error case: <unknown>
Media Status	LinkState	N/A, UP, DOWN	FO: N/A (always display N/A)
Media Status	TransceiverDetection	N/A, NO Transceiver detected, Transceiver detected	FO: N/A (always N/A) (NO Transceiver detected, Transceiver detected), Error case: N/A

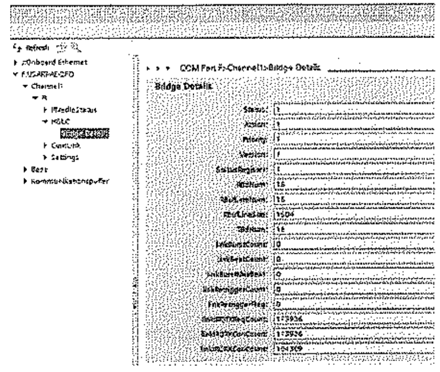

Figure 3-75 Diagnostic Data of the Protection-Interface Log - HDLC (Log - Layer)

Table 3-16 Description of Diagnostic Data of the Protection-Interface Log - HDLC (Log - Layer)

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

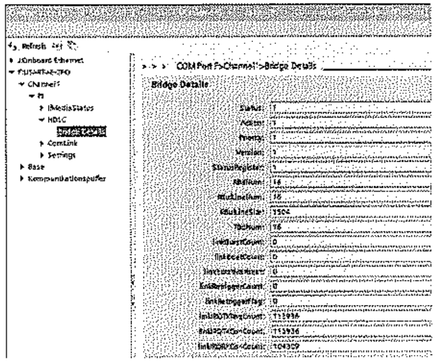

Figure 3-76 Diagnostic Data of the Protection Interface Log - COM Interface (External COM Link Interface Between Module and Mainboard)

Table 3-17 Description of Diagnostic Data of the COM Interface (External COM Link Interface Between Module and Mainboard)

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

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

Table 3-18 Description of Diagnostic Data of some Setting Values of the Protection Interface

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

3.5.3.12 Settings

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

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Addr.	Parameter	C	Setting Options	Default Setting
Prot.interface				
_:105	Prot.interface Connection via		• fiber optic • CCXG 512 kBit/s • CCXG 128 kBit/s • CCXG 64 kBit/s • repeater 512 kBit/s • CCPW 128 kBit/s • CC2M 512 kBit/s • C37.94 1 * 64 kBit/s • C37.94 2 * 64 kBit/s • C37.94 N * 64 kBit/s • 64 kBit/s • 128 kBit/s • 512 kBit/s • 2048 kBit/s	fiber optic
Prot. interf.1				
_:5161:1	Prot. interf.1:Mode		• off • on	on
_:5161:105	Prot. interf.1:Max. error rate per hour		0.000 % to 100.000 %	1.000 %
_:5161:106	Prot. interf.1:Max. error rate per min		0.000 % to 100.000 %	1.000 %
_:5161:107	Prot. interf.1:Disturbance alarm after		0.05 s to 2.00 s	0.10 s
_:5161:108	Prot. interf.1:Transm. fail. alarm after		0.0 s to 6.0 s	6.0 s
_:5161:109	Prot. interf.1:Delay time threshold		0.1 ms to 30.0 ms	30.0 ms
_:5161:110	Prot. interf.1:Difference Tx and Rx time		0.000 ms to 3.000 ms	0.100 ms
_:5161:113	Prot. interf.1:PPS synchronization		• telegr. and PPS • telegr. or PPS • PPS sync. off	PPS sync. off

3.5.3.13 Information List

No.	Information	Data Class (Type)	Type
Channel 1			
_:307	Prot.interface:Health	ENS	O
_:304	Prot.interface:Channel live	SPS	O
Device combin.			
_:5131:52	Device combin.:Behavior	ENS	O
_:5131:53	Device combin.:Health	ENS	O
_:5131:301	Device combin.:Status of topo. recog.	ENS	O
_:5131:302	Device combin.:Topology is	ENS	O
_:5131:303	Device combin.:Devices form	ENS	O
_:5131:304	Device combin.:Number of detect. dev.	INS	O
_:5131:305	Device combin.:Fct. logoff device 1	SPS	O
_:5131:306	Device combin.:Fct. logoff device 2	SPS	O
_:5131:307	Device combin.:Fct. logoff device 3	SPS	O
_:5131:309	Device combin.:Fct. logoff device 4	SPS	O

No.	Information	Data Class (Type)	Type
_:5131:310	Device combin.:Fct. logoff device 5	SPS	O
_:5131:311	Device combin.:Fct. logoff device 6	SPS	O
_:5131:312	Device combin.:Device 1 available	SPS	O
_:5131:313	Device combin.:Device 2 available	SPS	O
_:5131:314	Device combin.:Device 3 available	SPS	O
_:5131:315	Device combin.:Device 4 available	SPS	O
_:5131:316	Device combin.:Device 5 available	SPS	O
_:5131:317	Device combin.:Device 6 available	SPS	O
Prot. interf.1			
_:5161:81	Prot. interf.1:>Block stage	SPS	I
_:5161:500	Prot. interf.1:>Sync. reset	SPS	I
_:5161:341	Prot. interf.1:Reset synchronization	SPC	C
_:5161:342	Prot. interf.1:Reset measurements	SPC	C
_:5161:52	Prot. interf.1:Behavior	ENS	O
_:5161:53	Prot. interf.1:Health	ENS	O
_:5161:301	Prot. interf.1:Status of lay. 1 and 2	ENS	O
_:5161:302	Prot. interf.1:Status of lay. 3 and 4	ENS	O
_:5161:303	Prot. interf.1:Connection broken	SPS	O
_:5161:316	Prot. interf.1:Error rate / min exc.	SPS	O
_:5161:317	Prot. interf.1:Error rate / hour exc.	SPS	O
_:5161:318	Prot. interf.1:Time delay exceeded	SPS	O
_:5161:319	Prot. interf.1:Time delay different	SPS	O
_:5161:320	Prot. interf.1:Time delay jump	SPS	O
_:5161:321	Prot. interf.1:PI synchronized	SPS	O
_:5161:340	Prot. interf.1:Telegram lost	SPS	O
_:5161:308	Prot. interf.1:Tx tel/h	MV	O
_:5161:309	Prot. interf.1:Rx tel/h	MV	O
_:5161:310	Prot. interf.1:Tx tel/min	MV	O
_:5161:311	Prot. interf.1:Rx tel/min	MV	O
_:5161:312	Prot. interf.1:Tx err/h	MV	O
_:5161:313	Prot. interf.1:Rx err/h	MV	O
_:5161:314	Prot. interf.1:Tx err/min	MV	O
_:5161:315	Prot. interf.1:Rx err/min	MV	O
_:5161:334	Prot. interf.1:Miss.tel/min	MV	O
_:5161:335	Prot. interf.1:Miss.tel/h	MV	O
_:5161:336	Prot. interf.1:Miss.tel/d	MV	O
_:5161:337	Prot. interf.1:Miss.tel/w	MV	O
_:5161:338	Prot. interf.1:M. loss/d	MV	O
_:5161:339	Prot. interf.1:M. loss/w	MV	O
_:5161:331	Prot. interf.1:Recept.	MV	O
_:5161:323	Prot. interf.1:PPS: time del. unsym.	SPS	O
_:5161:324	Prot. interf.1:PI with PPS synchron.	SPS	O
_:5161:325	Prot. interf.1:Avg. Δt	MV	O
_:5161:326	Prot. interf.1:Rec. Δt	MV	O
_:5161:327	Prot. interf.1:Sen. Δt	MV	O

No.	Information	Data Class (Type)	Type
Ext. Synchron.			
_:9181:500	Ext. Synchron.:>Block stage	SPS	I
_:9181:501	Ext. Synchron.:>PPS pulse loss	SPS	I
_:9181:301	Ext. Synchron.:PPS pulse loss	SPS	O
_:9181:302	Ext. Synchron.:PPS pulse	SPS	O
Meas.val.dev.1			
_:1351:6811:300	Meas.val.dev.1:Dev.adr.	INS	O
_:1351:6811:301	Meas.val.dev.1:Line	ENS	O
_:1351:6811:302	Meas.val.dev.1:Vph	WYE	O
_:1351:6811:303	Meas.val.dev.1:Iph	WYE	O
Meas.val.dev.2			
_:1351:6841:300	Meas.val.dev.2:Dev.adr.	INS	O
_:1351:6841:301	Meas.val.dev.2:Line	ENS	O
_:1351:6841:302	Meas.val.dev.2:Vph	WYE	O
_:1351:6841:303	Meas.val.dev.2:Iph	WYE	O
Meas.val.dev.3			
_:1351:6871:300	Meas.val.dev.3:Dev.adr.	INS	O
_:1351:6871:301	Meas.val.dev.3:Line	ENS	O
_:1351:6871:302	Meas.val.dev.3:Vph	WYE	O
_:1351:6871:303	Meas.val.dev.3:Iph	WYE	O
Meas.val.dev.4			
_:1351:6901:300	Meas.val.dev.4:Dev.adr.	INS	O
_:1351:6901:301	Meas.val.dev.4:Line	ENS	O
_:1351:6901:302	Meas.val.dev.4:Vph	WYE	O
_:1351:6901:303	Meas.val.dev.4:Iph	WYE	O
Meas.val.dev.5			
_:1351:6931:300	Meas.val.dev.5:Dev.adr.	INS	O
_:1351:6931:301	Meas.val.dev.5:Line	ENS	O
_:1351:6931:302	Meas.val.dev.5:Vph	WYE	O
_:1351:6931:303	Meas.val.dev.5:Iph	WYE	O
Meas.val.dev.6			
_:1351:6961:300	Meas.val.dev.6:Dev.adr.	INS	O
_:1351:6961:301	Meas.val.dev.6:Line	ENS	O
_:1351:6961:302	Meas.val.dev.6:Vph	WYE	O
_:1351:6961:303	Meas.val.dev.6:Iph	WYE	O

3.6 Date and Time Synchronization

3.6.1 Overview of Functions

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

3.6.2 Structure of the Function

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

Set date and time:

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

Parameter:

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

Indications:

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

3.6.3 Function Description

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

Configurable Synchronization Options:

- **None (default setting)**
  The device functions without any external time synchronization. The internal time synchronization continues to work with the help of the back-up battery even when the auxiliary voltage is shut down temporarily. The time can be adjusted manually.
- **Telegram**
  The time is synchronized via a telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 or DNP3 protocol.
- **Connection to a radio clock**
  The time synchronization takes place with the set time telegram from an external IRIG-B or DCF77 receiver via the time synchronization interface of the device.
- **Ethernet**
  The time synchronization is done via Ethernet based SNTP protocol (Simple Network Time Protocol), for example with IEC 61850 stations or via IEEE 1588. If you enable both services during configuration of Ethernet interfaces, these protocols are available as an option for the time synchronization.
- **Protection interface**
  The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management.

ВЯРНО С ОРИГИНАЛА

Configurable Time Sources:

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

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

Configurable Date Format

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

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

Taking Local Time Zones into Account

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

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

Status, Supervision, and Indications of Time Management

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

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

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

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

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

DIGSI: Online access -> Interface -> Device -> Device information -> **Time Information**

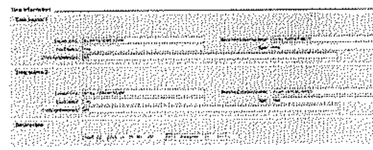

Figure 3-77 Time Information in DIGSI

For every time source, you see the following:

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

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

The lower section displays the device time, which is continuously updated. If the internal device time and the allied time source were synchronous at the time of telegram receipt, both displayed times are identical.

NOTE

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

3.6.4 Application and Setting Notes

Parameter: Date Format

- Default setting Date format = YYYY-MM-DD

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

Parameter Value	Description
YYYY-MM-DD	Day.Month.Year: Typical European display Example: 24.12.2010
YYYY-MM-DD	Month/Day/Year: Typical US representation Example: 12/24/2010
YYYY-MM-DD	Year-Month-Day: Typical Chinese display Example: 2010-12-24

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

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

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

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

Parameter: Time source 1,Time source 2

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

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

Parameter Value	Description
none	The time source is not configured.
IRIG-B	Time synchronization by an external GPS receiver: SIPROTEC 5 devices support several protocol variants of the IRIG-B standards. • IRIG-B 002(003) The control function bits of the signal are not occupied. The missing year is formed from the current device time. In this case, it is possible to set the year via the online access in DIGSI 5. • IRIG-B 006(007) The bits for the calendar year are not equal to 00. The calendar year is set automatically by the time protocol. • IRIG-B 005(004) with extension according to IEEE C37.118-2005 If, in the time signal, other control function bits are occupied in addition to the calendar year, then the device takes the additional information into consideration for leap seconds, daylight saving time, time offset (zone, daylight saving time) and time accuracy. Time zone time source 1 or Time zone time source 2: The value of this setting is not evaluated by the device, since this protocol either transmits or in the case of local time, specifies the appropriate offset to UTC in each set time telegram.
DCF77	Time synchronization by an external DCF 77 receiver Time zone time source 1 or Time zone time source 2 = local Please note: There are also clocks that generate a DCF 77 signal representing UTC. In this case, UTC must be set.
PI	The time synchronization takes place via the protection interfaces configured for your SIPROTEC 5 device. Here, the timing master takes over the time management. Signal-transit times of the protection interface communication are calculated automatically. Time zone time source 1 or Time zone time source 2 = UTC A slave that receives a time or a SIPROTEC 5 master, receives its system time kept in UTC.
SNTP	The time synchronization is done via the Ethernet service SNTP (SNTP server or via IEC 61850). SIPROTEC 5 devices support both Edition1 and Edition2 in accordance with IEC 61850-7-2. In Edition2, the logical attributes LeapSecondsKnown, ClockFailure, ClockNotSynchronized, and the value TimeAccuracy are maintained in each time stamp. For Edition1, these signals contain default settings. Thus, the interoperability for substation automation technology is ensured for both editions! The SNTP service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. Time zone time source 1 or Time zone time source 2 = UTC
IEC 60870-5-103	The time is synchronized via telegram with an appropriately configured communication interface in accordance with the IEC 60870-5-103 protocol. Time zone time source 1 or Time zone time source 2 = local However, there are also T103 systems that send the UTC.
DNP3	The time is synchronized via telegram with the appropriately configured communication interface in accordance with the DNP3 protocol. Two characteristics are supported in the process: • Time synchronization via UTC • Time synchronization with local time The daylight saving time status is not transmitted. The device assumes that the DNP3 master follows the same rules for the start and end of the daylight saving time as those that were set for the device. Time zone time source 1 or Time zone time source 2 = UTC is the current implementation. local concerns older implementations.
IEEE 1588	Time is synchronized via an IEEE 1588 timing master. In this case, SIPROTEC 5 devices operate as slave-only clocks. IEEE 1588 v2 is supported with P2P and Ethernet Transport. The IEEE 1588 service must be enabled during configuration of Ethernet interfaces so that it is available as an option for the time synchronization. Time zone time source 1 or Time zone time source 2 = UTC

Parameter: Fault Indication after

- Default setting Fault indication after = 600 s

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

Parameter: Time Zone and Daylight Saving Time

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

Figure 3-78 Settings for Time Zone and Daylight Saving Time in DIGSI

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

3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Time sync.				
_:102	Time sync.:Time source 1		• none • PPM • IRIG-B • DCF77 • Synchbox • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:103	Time sync.:Time source 1 port		• port J • port F • port E • port P • port N • port G	
_:104	Time sync.:Time source 1 channel		• Ch1 • Ch2	
_:105	Time sync.:Time source 2		• none • PPM • IRIG-B • DCF77 • Synchbox • PI • SNTP • IEC 60870-5-103 • PROFIBUS DP • Modbus • DNP3 • IEEE 1588 • IEC 60870-5-104	none
_:106	Time sync.:Time source 2 port		• port J • port F • port E • port P • port N • port G	
_:107	Time sync.:Time source 2 channel		• Ch1 • Ch2	
_:108	Time sync.:Time zone time source 1		• UTC • local	local
_:109	Time sync.:Time zone time source 2		• UTC • local	local
_:101	Time sync.:Fault indication after		0 s to 3600 s	600 s

3.6.6 Information List

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

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

3.7 User-Defined Objects

3.7.1 Overview

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

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

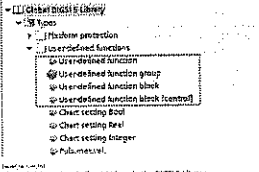

Figure 3-79 User-Defined Objects in the DIGSI 5 Library

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

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

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

You can find more information in chapter 6.6.1 Overview of Functions.

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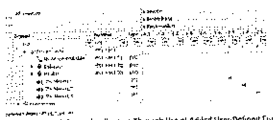

Figure 3-80 Information Routing Through Use of Added User-Defined Function Block: Process Indications and Single Point Indications

3.7.2 Basic Data Types

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

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

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

EXAMPLE

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

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

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

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

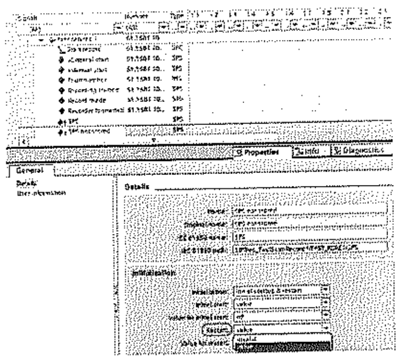

Figure 3-81 Single-Point Indication SPS Unsaved (Example: 7KE85 Fault Recorder)

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

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

EXAMPLE

Acquisition of a disconnector or circuit-breaker switch position.

Marker Command (Type SPC, Single-Point Controllable)

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

State of a Whole Number (Type INS)

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

EXAMPLE

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

State of an Enumeration Value (Type ENS)

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

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

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

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

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

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

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

Complex Measured Values (CMV)

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

Measured Values (MV)

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

> **NOTE**
>
> Additional data types can be found under other headings in the DIGSI 5 library as well as in the corresponding function blocks. This applies to the following data types:
> - Pulse-metered values (see **User-defined functions** in the DIGSI 5 library)
> - Transformer taps
> - Metered values

Phase-to-Ground Measured Values (WYE)

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

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

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

Protection Activation Information (ACT)

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

Protection Activation Information with Direction (ACD)

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

3.7.3 Pulse- and Energy-Metered Values, Transformer Taps

Pulse-Metered Values

Pulse-metered values are available as data types BCR (Binary Counter Reading) in the DIGSI library under **User-defined Functions**.

The functionality and the settings of the pulse-metered values can be found in chapter 10.8.1 *Pulse-Metered Values Function Description*.

Transformer Taps

Transformer taps are contained in the **Transformer tap changers** switching element. When the **Transformer tap changer** switching element is created in the device, the transformer tap position is available as a data object of type BSC (binary controlled tap changer with tap-position information).

You can find detailed information in 6.8.1 *Function Description*.

Energy-Metered Values

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

You can find more detailed information in chapter 10.7.1 *Function Description of Energy Values*.

3.7.4 Additional Data Types

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

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

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

3.8 Other Functions

3.8.1 Signal Filtering and Chatter Blocking for Input Signals

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

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

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

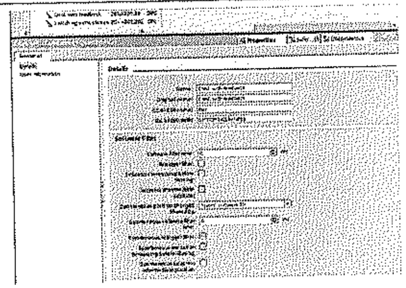

Figure 3-82 Settings for Circuit Breaker Switch Position

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

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

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

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

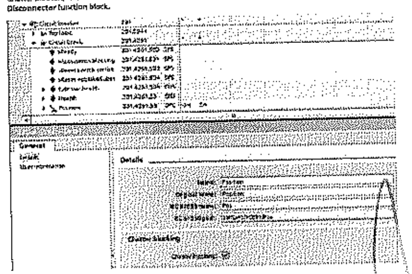

Figure 3-83 Setting Chatter Blocking

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

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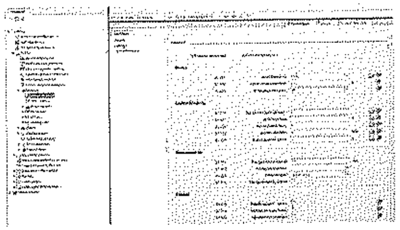

Figure 3-84 Chatter-Blocking Settings

The chatter-blocking settings have the following meaning (see also Figure 3-85 and Figure 3-86 in the examples shown in the following):

- No. permis. state changes

  This number specifies how often the state of a signal may toggle within the chatter test time and the chatter checking time. If this number is exceeded, the signal will be or remains blocked.

  Enter a number from 0 to 65535 in this field. If the entry is 0, chatter blocking is essentially inactive.

- Initial test time

  During this time, the number of times a signal changes its status is checked. This time is started if chatter blocking is configured for at least one signal and this signal changes its status. If the configured number of permissible state changes is exceeded during the initial test time, the signal is temporarily blocked and the indication Chatter blocking is set.

  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in seconds. When the set time has expired, the timer restarts automatically (cycle time).

- No. of chatter tests

  This number specifies the maximum number of test cycles to be run. If the number of permissible state changes stays exceeded during the initial test time of the last test cycle, the signal is finally blocked. In this case, the indication Group warning (Alarm handling group) and (Device group) are set additionally to the Chatter blocking indication after expiry of the set number. Restarting the devices removes this block again.

  Enter a number from 0 to 32767 in this field. The value infinite (∞) is also permissible here.

  Enter this value as character string oo.

- Chatter idle time

  If the number of permissible status changes for a signal is exceeded during the initial test time or the subsequent test time, the Chatter idle time starts. Within this time, this signal is blocked temporarily and the Chatter blocking indication is set. The blocked input signal is assigned the oscillatory quality.

  Enter a number between 1 and 65535 in this field. The number entered corresponds to the time in minutes. An entry here is only considered if the number of chatter tests does not equal 0.

- Subsequent test time

  During this second test time, the number of times a signal changes its status is checked once again. This time begins when the Chatter idle time expires. If the number of status changes is within the permissible limits, the signal is released. Otherwise, an additional idle time begins, unless the maximum number of chatter tests has been reached.

  Enter a number between 2 and 65535 in this field. The number entered corresponds to the time in seconds. An entry here is only considered if the number of chatter tests does not equal 0.

Example 1: Permanent Blocking

The chatter-blocking settings are set as follows:

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

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

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

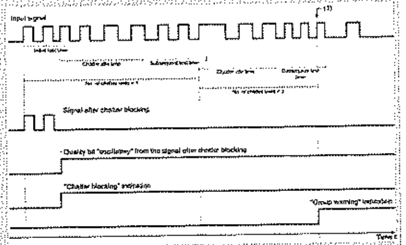

Figure 3-85 Signal Change during Chatter Blocking with too Important Number of Signal State Changes During 2nd Subsequent Test Time

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

Example 2: Temporary Blocking

The chatter-blocking settings are set as follows:

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

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

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

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

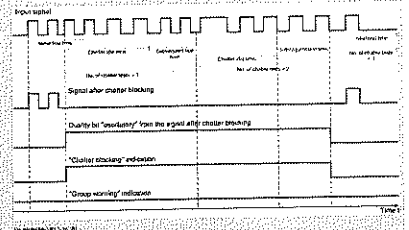

Figure 3-86 Signal Change during Chatter Blocking with Permissible Number of Signal State Changes During 2nd Subsequent Test Time

3.8.2 Acquisition Blocking and Manual Updating

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

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

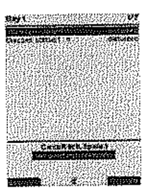

Figure 3-87 Activating the Acquisition Blocking

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

Figure 3-88 Activate Manual Updating

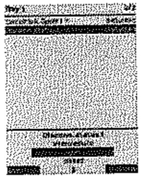

Figure 3-89 Selecting Position

NOTE

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

NOTE

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

Acquisition blocking can also be set via a binary input. This way, acquisition blocking can be set for an individual or several switching devices in a feeder simultaneously with an external toggle switch in order to disable the feeder. For this purpose, every switching device in the Switch function block (circuit breaker or disconnector switch) has the input signal >Acquisition blocking. This signal can also be set from the CFC.

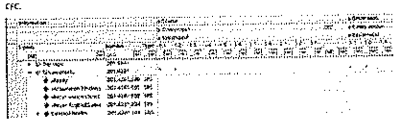

Figure 3-90 Input Signals >Acquisition Blocking and >Release Acquisition Block & Manual Updating on the Switching Device

NOTE

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

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

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

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

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

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

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

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

NOTE

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

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

3.8.3 Persistent Commands

In addition to the switching commands, which are issued as pulse commands, and stored for the standard switching devices (circuit breaker, disconnector switch), persistent commands are also possible. In this case, a distinction must be drawn between controllables with the Continuous output operating mode and a stored signal output that is immune to reset.

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

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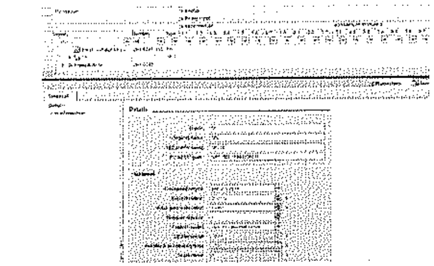

Figure 3-91 Setting the Command Type in DIGSI 5

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

3.9 General Notes for Setting the Threshold Value of Protection Functions

3.9.1 Overview

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

An innovative design was implemented for the protection settings.

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

- Primary
- Secondary
- Percent

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

Edit Mode: Primary

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

Edit Mode: Secondary

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

Edit Mode: Percent

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

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

Recommendation for Setting Sequence

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

- First set the transformation ratios of the transformers. You can find these under Power-system data.
- In addition, set the reference parameters for the percent setting. You will find these parameters in function group.
- Next, set the parameter of the protection functions.
  If the transformer data have changed after completing the protection setting, remain in the setting sheet (for example, primary setting) and change the transformer data. In the background, DIGSI 5 obtains the new settings in the inactive setting views (for example, new secondary values).

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

3.9.2 Modifying the Transformer Ratios in DIGSI 5

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

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

The following output data are assumed:

Current transformer:	1000 A/1 A
Protection pickup value:	1.5 A

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

Figure 3-92 Protection Setting, Display of the Active Setting Sheet

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

Figure 3-93 Switchover to the Desired Setting View

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

Figure 3-94 Setting Sheet:Transformer Data

In the Voltage/current 3-phase function group, you set the rated current and rated voltage (see the following figure). Rated current, rated voltage are the reference variables for the percent setting.

Figure 3-95 Reference Data for Percentage Settings

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

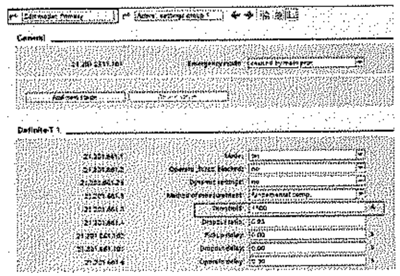

Figure 3-96 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Primary)

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

1500 A/1000 A · 100 % = 150 %

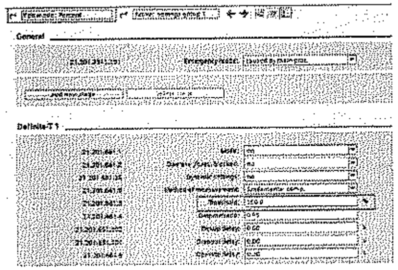

Figure 3-97 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Percent)

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

1500 A/(1000 A/1 A) = 1.5 A

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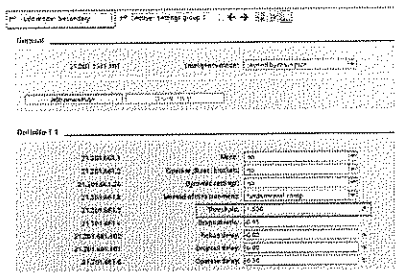

Figure 3-98 Example of the Threshold Value of the Definite Time-Overcurrent Protection (Edit Mode: Secondary)

If you only want to work in the secondary view, DIGSI 5 supports you if the transformer ratio changes during the project phase.

In the example, the current-transformer ratio changes from 1000 A/1 A to 1000 A/5 A. Change the secondary rated current of the current transformer in the setting sheet of the transformer data from 1 A to 5 A (Edit mode: Secondary). If you change the transformer data, a window will appear (see the following figure) that will ask you for the action desired.

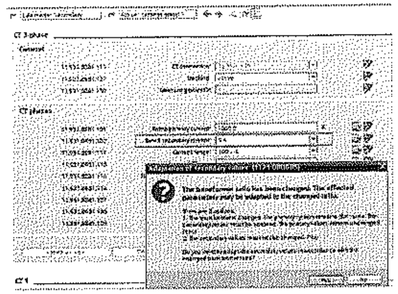

Figure 3-99 Query after Changing the Transformer Data (Setting View, Secondary)

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

The following figure shows the newly calculated threshold value in the secondary view.

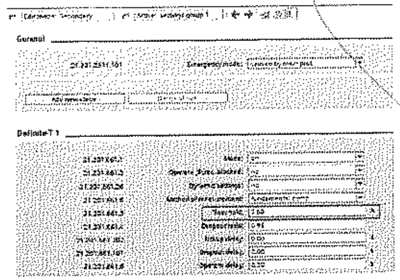

Figure 3-100 Automatically Recalculated Secondary Values After Changes in the Transformer Data

If you have already set the settings in the secondary view by including the new transformation ratio of the transformer in the calculation, then you answer the question with No. In this case, the protection settings in the secondary view remain unchanged. DIGSI 5 recalculates the settings (threshold values) of the primary view. In the example, the primary threshold value is then 300 A (1.5 A * 1000 A/5 A = 300 A).

In the example, the current-transformer ratio changes from 1000 A/1 A to 1000 A/5 A. The following table summarizes the pickup values that DIGSI 5 will recalculate in the setting view. The new values (in bold) depend on the answer of your inquiry (see Figure 3-99).

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

3.9.3 Changing the Transformation Ratios of the Transformer on the Device

The device is preset to the secondary value at the time of delivery. Only secondary values can be set directly on the device.

If you change transformer data directly on the device, it is not followed by a query, like in DIGSI 5 (see Figure 3-99). Instead, the device assumes that all settings remain unchanged in the secondary view.

NOTE

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

3.10 Device Settings

3.10.1 General Device Settings

3.10.1.1 Overview

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

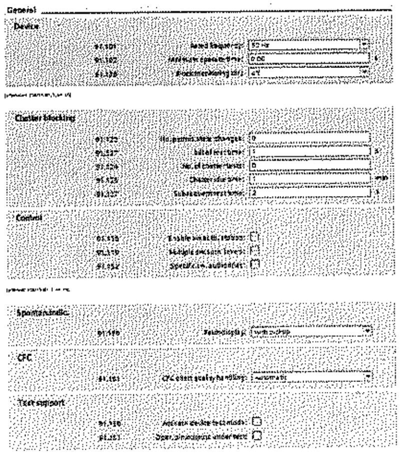

Figure 3-101 General Device Settings

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

You can find more about:

- **Chatter blocking** in chapter 3.8.1 *Signal Filtering and Chatter Blocking for Input Signals*.
- **Control** in chapter 8.3 *Control Functionality*.
- **Spontaneous indications** in chapter 3.1.7 *Spontaneous Indication Display in DIGSI 5*.
- **CFC Quality Processing** in Chapter 3.3.3 *Quality Processing/Affected by the User in CFC Charts*.

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

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

3.10.1.2 Application and Setting Notes

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

Parameter: Rated frequency

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

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

Parameter: Minimum operate time

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

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

Parameter: Block monitoring dir.

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

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

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

Parameter: Fault-display

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

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

Parameter: Activate device test mode

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

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

Parameter: Oper.bin.outp. under test

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

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

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

NOTE

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

3.10.1.3 Settings

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

3.10.1.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:510	General:>Test mode on	SPS	I
_:511	General:>Test mode off	SPS	I
_:507	General:>Device funct.logoff on	SPS	I
_:508	General:>Dev. funct.logoff off	SPS	I
_:512	General:>LED reset	SPS	I
_:52	General:Behavior	ENS	O
_:53	General:Health	ENS	O
_:51	General:Test mode	ENC	C
_:971	General:Protection on	SPC	C
_:54	General:Protection inactive	SPS	O
_:323	General:LED reset	SPC	C
_:320	General:LED have been reset	SPS	O

3.10.2 Settings-Group Switching

3.10.2.1 Overview of Functions

For different applications you can save the respective function settings in so-called **Settings groups**, and if necessary enable them quickly.

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You can save up to 8 different settings groups in the device. In the process, only one settings group is active at any given time. During operation, you can switch between settings groups. The source of the switchover can be selected via a parameter.

You can switchover the settings groups via the following alternatives:

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

A settings group includes all switchable settings of the device. Except for a few exceptions (for example, general device settings such as rated frequency), all device settings can be switched.

Detailed information about the settings groups can be found in the Operating Manual and DIGSI 5 Online Help.

3.10.2.2 Structure of the Function

The function of the Settings group switching is a supervisory device function. Accordingly, the settings and indications of the settings group switching can be found in DIGSI 5 and at the on-site operation panel of the device, below the general device settings respectively.

If you want to switchover a settings group, navigate in DIGSI 5 or proceed on the on-site operation panel of the device, as follows:

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

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

3.10.2.3 Function Description

Activation

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

Mechanism of the Switchover

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

Switching via Control

When using the `Control` function for switching, the settings groups can be switched via a communication connection from the substation automation technology or via a CFC chart.

The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.

In order to use a CFC chart for switching, you must create a new CFC chart in DIGSI 5. Create the CFC chart in the DIGSI 5 project tree under **Name of the device** → **Charts** → **Add new chart**. Link the signals that control settings group switching in the CFC chart.

Switching via Binary Input

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

Table 3-19 Binary Codes of the Input Signals and Applicable Settings Groups

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

Copying and Comparing Settings Groups

In DIGSI 5, you can copy or compare settings groups with each other.

If you want to copy settings groups, select a source and target parameter group in DIGSI 5 in the device settings, and then start the copy process. The device settings can be found in the DIGSI 5 project tree under Project → Device → Settings → Device settings.

If you want to compare settings groups, it is possible to do so in all setting sheets for settings. You will then select in addition to the active settings group, a 2nd settings group for comparison. Active setting values and the comparable values are displayed next to each other. For settings that cannot be switched over, no comparable values are displayed.

Indication of Settings Group Switchings

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

3.10.2.4 Application and Setting Notes

Parameter: Number settings groups

- Default setting (_:113) `Number settings groups` = 2

With the `Number settings groups` parameter, you can set the number of available settings groups that you can switch between them.

Parameter: Activat. of settings group

- Default setting (_:114) `Activat. of settings group` = `settings group 1`

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

Parameter Value	Description
`via control`	The switchover between the settings groups can only be initiated via a communication connection from a substation automation technology or via a CFC chart. The communication protocols IEC 60870-5-103, IEC 60870-5-104, IEC 61850, DNP or Modbus TCP can be used for switching the settings groups via a communication connection.
`via binary input`	The switchover between the settings groups functions exclusively via the binary input signals routed to the settings group switching.

`settings group 1`
...
`settings group 8`
	They define the active settings groups. You can define the active settings groups in DIGSI 5, or directly on the device via the on-site operation.

3.10.2.5 Settings

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

3.10.2.6 Information List

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

4 Applications

4.1 Overview

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

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

When using an application template, please note the following:

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

The following describes the application templates and maximum functional scope for the devices shown in this manual.

NOTE

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

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4.2 Application Templates and Functional Scope for the Devices 7SJ82/7SJ85

Application templates are available in DIGSI 5 for the applications of the device 7SJ82/7SJ85. The application templates contain the basic configurations, required functions, and default settings.

The following application templates are available for the device 7SJ82 and 7SJ85 in the DIGSI 5 function library:

- Non-directional OC (4*I)
- Non-directional OC (4*I, 4*V)
- Directional OC, grounded system
- Directional OC, resonant-grounded/isol. system
- Capacitor bank H-bridge + 1*RLC, 7SJ85 only
- Capacitor bank MSCDN, 7SJ85 only
- Capacitor bank H-bridge, 7SJ82 only

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

Application Template		Hardware Configuration Minimum Requirement
Template 1	Non directional OC (4*I)	9 BI, 6 BO, 4 I
Template 2	Non directional OC (4*I, 4*V)	9 BI, 8 BO, 4 I, 4 V
Template 3	Directional OC, grounded system	
Template 4	Directional OC, resonant-grounded /isol. system	
Template 5	Capacitor bank: H-bridge + 1*RLC	2 BI, 2 BO, 12 I
Template 6	Capacitor bank: MSCDN	2 BI, 2 BO, 28 I, 4 V
Template 7	Capacitor bank: H-bridge	2 BI, 2 BO, 8 I

The following table shows the functional scope and the required function points of the application templates for the device 7SJ82/7SJ85:

Table 4-1 Functional Scope of the Application Template for the Device 7SJ82/7SJ85

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
	Protection functions for 3-pole tripping	3-pole	x	x	x	x	x	x	x	x	x
	Hardware quantity structure expandable	I/O	x	x	x	x	x	x	x	x	x
24	Overexcitation protection	V/f	x	x							
25	Synchronization, synchronizing function	Sync	x	x							
27	Undervoltage protection, 3-phase	V<	x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
27	Undervoltage protection, positive-sequence system	V1<	x	x							
27	Undervoltage protection, 3-phase, universal, Vx	V<	x	x							
27	Undervoltage protection, 1-phase, universal, Vx	Vx<	x	x							
27/Q	Undervoltage-controlled reactive-power protection	Q/U	x	x							
32R	Reverse-power protection	-P<	x	x							
32, 37	Power protection active/reactive power	P<>, Q<>	x	x							
37	Undercurrent protection x	I<	x	x					x	x	x
38	Temperature Supervision	TmpSub	x	x							
46	Negative-sequence overcurrent protection	I2>	x	x					x	x	x
46	Unbalanced load protection (thermal)	I2²t>	x	x							
46	Negative-sequence overcurrent protection with direction	I2>, ∠ (V2, I2)	x	x							
49	Thermal overload protection	θ, I²t	x	x					x	3	x
49	Thermal overload protection with user-def. charact. curve	θ, I²t	x	x						3	x
49	Thermal overload protection for RLC element	θ, I²t	x	x					x		
50TD/51	Overcurrent protection, phases - advanced	I>	x	x					x		
50TD/51	Overcurrent protection, phases - basic	I>	x	x	x	x	x	x		3	x
50NTD/51N	Overcurrent protection, ground advanced	IN>	x	x					x		
50NTD/51N	Overcurrent protection, ground - basic	IN>	x	x	x	x	x			x	x

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
50/51N 51N	Overcurrent protection, 1-phase advanced	I>1ph	x	x							
50N/51N	Overcurrent protection, 1-phase - basic	I>1ph	x	x							
50HS	High-speed instantaneous overcurrent protection	I>>>	x	x							
50Ns/51Ns	Sensitive ground-current protection for systems with resonant or isolated neutral	INs>	x	x							
50BF	Circuit-breaker failure protection		x	x						x	
50RS	Restrike protection		x	x							
51-R	OC-3ph-protection for RLC elements		x	x							
51V	OC-3phase voltage-dependent		x	x							
59	Overvoltage protection, 3-phase	V>	x	x						x	
59	Overvoltage protection, positive-sequence system	V1>	x	x							
47	Overvoltage protection, negative-sequence system	V2>	x	x							
47	Overvoltage protection with negative-sequence voltage/positive-sequence voltage	V2/V1>	x	x							
59N	Overvoltage protection, zero-sequence system	V0>	x	x							
59	Overvoltage protection, 3-phase or 1-phase, universal, Vx	Vx>	x	x							
59C	Peak overvoltage protection for capacitors		x	x					x	2	x
60C	Current unbalance protection for capacitors, 3-phase	Iunbal>	x	x					x	x	x
60C	Current Unbalance Protection for Capacitors, 1-phase	Iunbal>	x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
67	Directional overcurrent protection 1-pole			x							
67	Directional time-overcurrent protection, phases - advanced	I>, ∠ (V,I)	x	x							
67	Directional time-overcurrent protection, phases - basic	I>, ∠(V,I)	x	x			x	x			
67N	Directional overcurrent protection, ground - advanced	IN>, ∠ (V,I)	x	x							
67N	Directional time over current protection, ground - basic	IN>, ∠ (V,I)	x	x			x				
67Ns	Directional sensitive ground-fault detection for systems with resonant or isolated neutral	INs>, ∠ (V,I)	x	x				x			
67Ns	Transient ground-fault function, for transient and permanent ground faults in resonant-grounded or isolated networks	W0p,tr>	x	x							
74TC	Trip-circuit supervision	TCS	x	x							
79	Automatic reclosing	AREC	x	x							
81O	Overfrequency protection	f>	x	x							
81U	Underfrequency protection	f<	x	x							
81R	Rate of frequency change protection	df/dt	x	x							
86	Lockout		x	x	4	4	4	4	x	x	x
87C	Capacitor bank differential protection		x	x						x	
87V	Voltage-differential protection	ΔV		x							
87N	Restricted ground-fault protection	ΔIN	x	x							
90V	Voltage controller		x	x							
Arc Prot	Arc protection		x	x							
DIGFP	Directional intermittent ground-fault protection		x	x							
IGFP	Intermittent ground-fault protection		x	x							

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
FL	Fault locator, single ended measurement	FL-one	x	x							
PMU	Synchrophasor measurement	PMU	x	x							
SOTF	Instantaneous tripping at switch onto fault	SOTF	x	x	x	x	x	x			
Mon/t	Circuit-breaker wear monitoring		x	x							
VSEL	Voltage measuring-point selection		x	x							
20mA MT	20-mA unit Ethernet		x	x							
20mA MS	20 mA unit serial		x	x							
RTDMT	RTD unit Ethernet		x	x							
RTDMS	RTD unit Serial		x	x							
	Signaling Voltage Supervision		x	x							
	Measuring-voltage failure detection		x	x							
	Switch onto fault		x	x	x	x	x	x			
	CB Test		x	x	x	x	x	x	x	x	x
	Interlocking		x	x	4	4	4	4	x	x	x
	I-jump detection		x	x							
	V-jump detection		x	x							
	Pulse metered value		x	x							
	Measured values, standard		x	x	x	x	x	x	x	?	x
	User-defined function block		x	x							
	Measured values, extended: Min, Max, Avg		x	x							
	Switching statistic counters		x	x							
	CFC standard and control		x	x	x	x	x	x	x	x	x
	CFC arithmetic		x	x							
	Switching sequences function		x	x							
	Inrush current detection		x	x	x	x	x	x			
	External trip initiation		x	x							
	Control		x	x	4	4	4	4	x	x	x

ANSI	Function	Abbr.	Available in 7SJ82	Available in 7SJ85	Template 1	Template 2	Template 3	Template 4	Template 5	Template 6	Template 7
	Fault recording of analog and binary signals		x	x	x	x	x	x	x	x	x
	Monitoring and supervision		x	x	x	x	x	x	x	x	x
	Protection interface, serial		x	x							
	Capacitor bank		x	x					x	2	x
	Circuit Breaker		x	x	x	x	x	x	x	x	x
	Circuit Breaker (control)		x	x							
	Circuit Breaker (status only)		x	x							
	Disconnector		x	x	3	3	3	3			
	Disconnector (status only)		x	x							
	Tap changer		x	x							
	Analog unit		x	x							
	Communication modules		x	x	x	x	x	x	x	x	x
	Function-points class:				0	0	30	45	90	295	80

ВЯРНО С ОРИГИНАЛА

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5 Function-Group Types

5.1 Function-Group Type Voltage-Current 3-Phase

5.1.1 Overview

All functions for protection and supervision of a protected object or equipment allowing 3-phase current and voltage measurement can be used in the function group Voltage-current 3-phase. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter 10 *Measured Values, Energy Values, and Supervision of the Primary System*).

You will find the **Voltage-current 3-phase** function group under each device type in the Global DIGSI 5 library. You will find all protection and supervision functions that you can use for this function-group type in the function group **Voltage-current 3-phase**. These functions are described in chapter 6 *Protection and Automation Functions*.

You can find additional information on the embedding of the functions in the device in chapter 2 *Basic Structure of the Function*. You can find the function scope of the application templates for the various device types in the chapter 4 *Applications*.

5.1.2 Structure of the Function Group

The function group always contains the following blocks:

- Protected object/equipment data (FB General)
- Operational measured values
- Process monitor
- Output logic of the function group
- Reset LED group

These blocks are essential for the function group under all circumstances, so they cannot be loaded or deleted.

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

The following figure shows the structure of the function group **Voltage-current 3-phase**.

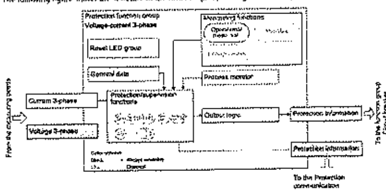

Figure 5-1 Structure of the Voltage-Current 3-Phase Function Group

The function group has interfaces with

- Measuring points
- Circuit-breaker function group

Interface with Measuring Points

The function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the function group is already connected to the necessary measuring points. If you add functions to the function group, they will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary measuring point is not connected, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 via the **Function group connections** editor. You can find more detailed information in chapter 2 *Basic Structure of the Function*.

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

- **3-phase current**

  The measurands from the 3-phase power system are supplied via this interface. Depending on the connection type of the transformers, these are, for example, I_A, I_B, I_C, I_N or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The function group must always be connected to the I-3ph measuring point.

  You can connect the **3-phase current** interface to a maximum of four 3-phase current measuring points (for example, for 1 1/2 circuit-breaker layouts). If 2 current measuring points have been connected with the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the function group. All functions in the function group have access to these values.

- **3-phase voltage (optional)**

  The measurands from the 3-phase voltage system are supplied via this interface. There are various types of transformer connections possible. All values that can be calculated from the measurands are also provided via this interface. Connecting the function group to the **V 3ph** measuring point is optional.

  You can connect multiple measuring points with this interface. You can find more information in chapter 6.45 *Voltage Measuring-Point Selection*.

  If you want to test or change the connection between the voltages and the V-3ph measuring point, double-click in the DIGSI 5 project tree → **(Name of the device)** on **Measuring point routing** (Connection type = 3 phase-to-ground voltage). For more information, refer to the description of the power-system data starting in chapter 6.1 *Power-System Data*.

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and **Circuit-breaker** function groups via the interface with the **Circuit-breaker** function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

The **Voltage-current 3-phase** function group is connected to one or more Circuit-breaker function groups. This connection generally determines:

- Which circuit breaker(s) is/are activated by the protection functions of the protection function group
- Starting the Circuit-breaker failure protection function (if available in the Circuit-breaker function group) through the protection functions of the connected protection function group
- Starting the Automatic reclosing function (AREC, if available in the Circuit-breaker function group) through the protection functions of the connected Protection function group

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

In the detail configuration of the interface, you define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the automatic reclosing function
- Which protection functions start the Circuit-breaker failure protection function

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

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

If the connection is missing, DIGSI 5 reports an inconsistency.

Protected Object/Equipment Data (FB General)

The rated voltage and rated current as well as the neutral-point treatment of the protected object or the equipment are defined here. These data apply to all functions in the **Voltage-current 3-phase** function group.

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

You can find more detailed information in chapter 3.1.10 *Resetting Stored Indications of the Function Group*.

Process Monitor

The process monitor is always present in the **Voltage-current 3-phase** function group and cannot be removed.

The process monitor provides the following information in the **Voltage-current 3-phase** function group:

- Current-flow criterion:
  Detection of an open/activated protected object/equipment based on the flow of leakage current
- Closure detection:
  Detection of the switching on of the protected object/equipment
- Cold-load pickup detection (optional, only for protection devices):

These data apply to all functions in the **Voltage-current 3-phase** function group.

The description of the process monitor begins in chapter 5.8 *Process Monitor*.

Operational Measured Values

The operational measured values are always present in the **Voltage-current 3-phase** function group and cannot be removed.

The following table shows the operational measured values of the **Voltage-current 3-phase** function group:

Table 5-1 Operational Measured Values of the Voltage-Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral-point phase current	A	A	Rated operating current of the primary values
I_{Ns}	Sensitive ground current	A	mA	Rated operating current of the primary values
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary values
V_0	Zero-sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P_{total}	Active power (total power)	MW	W	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$

Measured Values		Primary	Secondary	% Referenced to
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	W	Active power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	var	Reactive power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$
S_A, S_B, S_C	Phase-related apparent power	MVA	VA	Apparent power of the phase $V_{rated\,phs} \cdot I_{rated\,phs}$

The operational measured values are explained in more detail in chapter 10.3 *Operational Measured Values*.

Inversion of Power-Related Measured and Statistical Values (FB General)

The following directional values calculated in operational measured values are defined positively in the direction of the protected object.

- Power
- Active power factor
- Energy
- Minimum, maximum values
- Average values

With the **P, Q sign** parameter, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.

More information can be found in chapter 10.1 *Overview of Functions*.

Output Logic

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

The pickup signals of the protection and supervision functions in the **Voltage-current 3-phase** function group are combined in a phase-selective manner and output as a group indication.

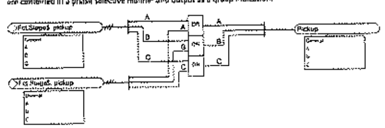

Figure 5-2 Creation of the Pickup Indication of the Voltage-Current 3-Phase Function Group

The trip signals from the protection and supervision functions of the **Voltage-current 3-phase** function group always result in 3-pole tripping of the device.

Figure 5-3 Creation of the Operate Indication of the Voltage-Current 3-Phase Function Group

5.1.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

With this, you define which circuit-breaker(s) is/are affected by the protection functions of the Protection function group. A feasible default setting has already been provided in the application templates. You can find more information in chapter 2.

Protected Object/Equipment Data (FB General)

The set data applies to all functions in the function group.

Set the protected object/equipment data for your specific application.

Parameter: Rated current

- Default setting (_:9451:101) Rated current = 1000 A

With the Rated current parameter, you can set the primary rated current of the protected object or equipment. The Rated current parameter is significant for protection functions, as long as the current values are set in percentages. In this case it is the reference value. In addition it is the reference value for the measured values in percent.

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

Parameter: Rated voltage

- Default setting (_:9451:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you can set the primary rated voltage of the protected object or equipment. The Rated voltage parameter is significant for protection functions, as long as the current values are set in percentages. In this case it is the reference value. In addition it is the reference value for the measured values in percent.

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

Parameter: Power-sys. neutral point

- Default setting (_:9451:149) Power-sys. neutral point = grounded

With the Power-sys. neutral point setting, you specify whether the system neutral is grounded, isolated, or suppres. coil grounded (grounded via arc suppression coil). Currently, the parameter does not affect any protection function; only if the **Automatic reclosing function** uses the voltage measurement).

You can find more information in Chapter 6.43.1 *Overview of Functions*.

Parameter: P, Q sign

- Default setting (_:9451:158) P, Q sign = not reversed

The power and energy values are defined by the manufacturer such that power in the direction of the protected object is considered positive. You can also define the power output by the protected object (for example, as seen by the consumer) as positive. With the P, Q sign setting, you can invert the sign for these components. This inversion does not influence any protection functions.

5.1.4 Write-Protected Settings

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

Addr.	Parameters	C	Range of Values	Default Setting
Network data				
_:103	General:Rated apparent power		0.20 MVA to 5 000.00 MVA	692.82 MVA

NOTE

You can find more detailed information on the Process monitor in chapter 5.6 Process Monitor.

5.1.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9451:101	General:Rated current		1 A to 100000 A	1000 A
_:9451:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Power-system data				
_:9451:149	General:Power-sys. neutral point		• grounded • suppress. coil grounded • isolated	grounded
Measurements				
_:9451:158	General:P, Q sign		• not reversed • reversed	not reversed

5.1.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:9451:52	General:Behavior	ENS	O
_:9451:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

No.	Information	Data Class (Type)	Type
Closure detec.			
_:1131:4681:500	Closure detec.:>Disconnector open	SPS	I
_:1131:4681:300	Closure detec.:Closure	SPS	O

5.2 Function-Group Type Voltage-Current 1-Phase

5.2.1 Overview

In the Voltage-current 1-phase function group, all functions can be used for protection and for monitoring a protected object or equipment which allow a 1-phase current and voltage measurement or a zero-sequence voltage measurement via a 3-phase voltage measuring point. The function group also contains the operational measurement for the protected object or equipment (on this topic, see chapter 10 Measured Values, Energy Values, and Supervision of the Primary System).

5.2.2 Structure of the Function Group

The Voltage-current 1-phase function group has interfaces to the measuring points and the Circuit-breaker function group.

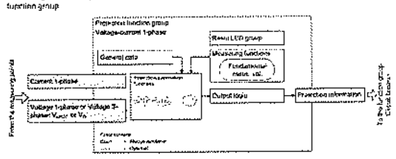

Figure 5-4 Structure of the Voltage-current 1-Phase Function Group

Interface with Measuring Points

You connect the Voltage-current 1-phase function group to the current and voltage measuring points via the interfaces to the measuring points. At least one measuring point has to be connected. The other is optional. This assignment can only be made in DIGSI via **Project tree → Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

The function group has the following interfaces to the measuring points.

- **1-phase current**
  The 1-phase current measured values are supplied via this interface.
  You can connect multiple measuring points with the 1-phase current interface.
- **1-phase voltage or 3-phase voltage**
  You can connect the voltage interface of the function group with a 1-phase or a 3-phase measuring point. The calculated zero-sequence voltage or the measured residual voltage are available for connection with a 3-phase measuring point. The phase-to-ground voltages are not available in the function group Voltage-current 1-phase. You can use both connection types at the same time.
  You configure the 1-phase voltage measuring points via the voltage interface (see the following figure).

Connect measuring points to function group
Circuit breaker 1 | VI 1ph 1
Measuring point | I-sync1 | V-sync2 | V | 1ph
(All) | (All) | (All) | (All) | (All)
Meas. point I-1ph 1 (ID 1) | X
Meas. point V-1ph 1 (ID 2) | X

Figure 5-5 Connecting Measuring Points to the Voltage-current 1-Phase Function Group

The converted, calculated zero-sequence voltage or measured residual voltage from the 3-phase voltage system is available via the voltage interface (see following figure).

Connect measuring points to function group
Circuit breaker 1 | VI 1ph 1
Measuring point | V-sync1 | V-sync2 | V | 1ph
(All) | (All) | (All) | (All) | (All)
Meas. point I-1ph 1 (ID 1) | X
Meas. point V-3ph 1 (ID 3) | X

Figure 5-6 Connecting Measuring Points 3-Phase Voltage and 1-Phase Current to the 1-Phase Voltage-Current Function Group

You can connect the voltage interface with precisely one 3-phase voltage measuring point. 3 types of 3-phase voltage measuring-point connections are supported. With the different connection types, the type of voltage input also changes in line with the functions. The following table shows the characteristics of the voltage input depending on the types of connection.

Connection Type of the 3-Phase Voltage Measuring Point	Voltage Input
3 ph to gnd voltages	The zero-sequence voltage is calculated from the phase-to-ground voltages and used as a voltage input for all functions.
3 ph-to-gnd volt. + VN	The residual voltage VN is converted to the voltage equivalent of the zero-sequence voltage. The converted voltage is used as a voltage input for functions.
3 ph-to-ph volt. + VN	

Interface to the Circuit-Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit-breaker function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit-breaker function group.

You must connect the **Voltage-current 1-phase** function group with the **Circuit-breaker** function group. The assignment can only be made in DIGSI via **Project tree → Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix. If the interface is not connected, the functions operate as supervision functions in the **Voltage-current 1-phase** function group.

Connect function group to circuit-breaker groups
Protection group | Circuit breaker 1
(All) | (All)
VI 1ph 1 | X

Figure 5-7 Connecting Voltage-current 1-Phase Function Group with Circuit-Breaker Function Group

Fundamental Components

The fundamental components are always present in the Voltage-current 1-phase function group and cannot be deleted.

The following table shows the fundamental components of the Voltage-current 1-phase function group:

Table 5-2 Fundamental Components of the Voltage-current 1-Phase Function Group

Measured Values		Primary	Secondary	% Referring to
I	1-phase current	A	A	Rated operating current
V[2]	1-phase voltage	kV	V	Rated operating voltage
V_0[3]	Zero-sequence voltage	kV	V	Rated operating voltage/√3
V_N[4]	Residual voltage	kV	V	Rated operating voltage/√3

5.2.3 Application and Setting Notes

NOTE

Prior to creation of the protection functions in the function group, these functions should first be connected to the appropriate Circuit-breaker function group.

Parameter: Rated current

- Default setting (_:9451:101) Rated current = 1000 A

The Rated current parameter is used to set the primary rated current. The Rated current specified here is the reference value for the percentage measured values and setting values made in percentages.

Parameter: Rated voltage

- Default setting (_:9421:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the Circuit-breaker function group.

5.2.4 Write-Protected Settings

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

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:9421:104	General:Rated apparent power		0.20 MVA to 5000.00 MVA	400.00 MVA
Network data				
_:91:211	General:M I 1ph uses measuring point ID		0 to 100	0
_:91:223	General: Scale factor M I-1ph		0.01 to 100.00	1.00

[2] The 1-phase voltage V is only visible if it is connected to a 1-phase voltage measuring point.
[3] The zero-sequence voltage V0 is only visible if it is connected to a 3-phase voltage measuring point with the 3-phase phase-to-ground voltage connection type.
[4] The residual voltage VN is only visible if it is connected to a 3-phase voltage measuring point with the 3-phase phase-to-ground voltage connection type + VN or 3-phase phase-to-phase voltage + VN.

5.2.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:101	General:Rated current		1 A to 100000 A	1000 A
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Power-system data				
_:9421:214	General:M I-1ph uses MeasP with ID		0 to 100	0
_:9421:127	General:Number of Meas.point. 1ph		0 to 11	0

5.2.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:9421:52	General:Behavior	ENS	O
_:9421:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:4741:500	Reset LED Group:>LED reset	SPS	I
_:4741:320	Reset LED Group:LED have been reset	SPS	O

ВЯРНО С ОРИГИНАЛА

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5.3 Function-Group Type Voltage 3-Phase

5.3.1 Overview

In the Voltage 3-phase function group, all functions can be used for protecting and for monitoring a protected object or equipment which allows a 3-phase voltage measurement. The function group also contains the operational measurements for the protected object or equipment (on this topic, see chapter 10 Measured Values, Energy Values, and Supervision of the Primary System). Applicable functions are, for example, Voltage protection or Frequency protection.

5.3.2 Structure of the Function Group

The Voltage 3-phase function group has interfaces to the measuring points and the Circuit-breaker function group.

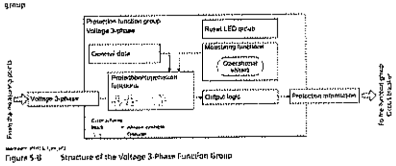


Figure 5-8 Structure of the Voltage 3-Phase Function Group

Interface with Measuring Points

You connect the **Voltage 3-phase** function group to the voltage measuring points via the interface to the measuring points. This assignment can only be made in DIGSI via **Project tree → Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

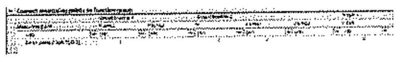


Figure 5-9 Connecting Measuring Points to the Voltage 3-Phase Function Group

If you add functions to the **Voltage 3-phase** function group, these are connected to the measuring point automatically.

You can connect multiple measuring points with this interface. You can find more information in chapter 6.48 Voltage Measuring-Point Selection.

The measurands from the 3-phase voltage system are supplied via the V 3-ph interface. Depending on the type of transformer connections, these are, for example, V_A, V_B, V_C, V_{N}. All values that can be calculated from the measurands are also provided via this interface.

Interface to the Circuit Breaker Function Group

All required data is exchanged between the protection and circuit-breaker function groups via the interface with the Circuit-breaker function group. In this example, the pickup and operate indications of the protection functions are exchanged in the direction of the Circuit-breaker function group.

You must connect the Voltage 3-phase function group with the Circuit-breaker function group. This assignment can be made in DIGSI only via **Project tree → Connect function group**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

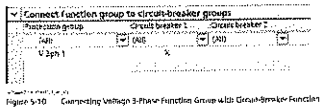


Figure 5-10 Connecting Voltage 3-Phase Function Group with Circuit-Breaker Function Group

Operational Measured Values

The operational measured values are always present in the **Voltage 3-phase** function group and cannot be deleted.

The following table shows the operational measured values of the **Voltage 3-phase** function group:

Table 5-3 Operational Measured Values of the Voltage 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Operating rated voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase to phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Zero sequence voltage	kV	V	Operating rated voltage of primary values/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Operating rated voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency

5.3.3 Application and Setting Notes

NOTE

Before creating the protection functions in the function group, you should first connect these functions to the appropriate Circuit-breaker function group.

Parameter: Rated voltage

- Default setting (_:9421:102) Rated voltage = 400.00 kV

With the Rated voltage parameter, you set the primary rated voltage. The Rated voltage set here is the reference value for the percentage-measured values and setting values made in percentages.

5.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:9421:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV

5.3.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:9471:52	General:Behavior	ENS	O
_:9471:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED FG			
_:4741:500	Reset LED Group:LED reset	SPS	I
_:4741:320	Reset LED Group:LED have been reset	SPS	O

5.4 Function-Group Type Capacitor Bank

5.4.1 Overview

In the Capacitor bank function group, all the functions that are necessary for protecting and monitoring a capacitor bank can be used.

You can find the **Capacitor bank** function group under 7SJ82/7SJ85 device types in the Global DIGSI 5 Library. The Capacitor bank function group contains all of the protection and supervision functions that you can use for this device type.

Some of these functions are exclusively used for protecting capacitor banks, and others are universal standard functions which can be used for other protected objects as well. You find the exclusive protection functions in the directory **Capacitor bank protection**.

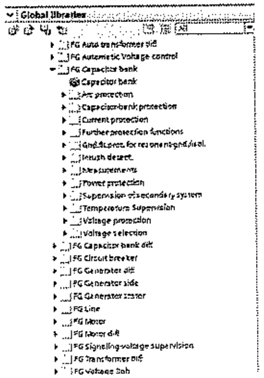


Figure 5-11 Capacitor Bank Function Group – Functional Scope for Device Type 7SJ85

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

5.4.2 Structure of the Function Group

The **Capacitor bank** function group always contains the following functionality:

- Protected object/equipment data (function block **General**)
- Operational measured values
- Capacitor bank device status and blocking by discharging (function block **General**)
- Process monitor
- Global compensation (function block **General**)
- Output logic of the function group
- Reset LED group

This functionality is essential for the **Capacitor bank** function group, so it cannot be loaded or deleted.

You can load the protection functions and supervision functions required for your application in the **Capacitor bank** function group. The functions are available from the Global DIGSI 5 Library. Functions that are not needed can be deleted from the function group.

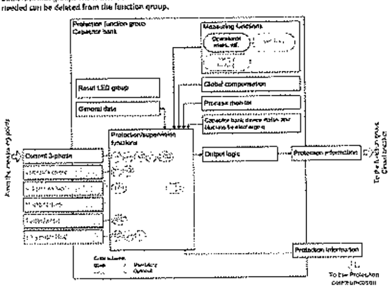


Figure 5-12 Structure of the Capacitor Bank Function Group

The Capacitor bank function group has interfaces with the following parts:

- Measuring points
- Circuit-breaker function group

Interfaces with the Measuring Points

The **Capacitor bank** function group receives the required measured values via the interfaces with the measuring points. If you are using an application template, the **Capacitor bank** function group is already connected to the specific measuring points.

You can find more detailed information in Chapter 2.

The **Capacitor bank** function group has the following 6 interfaces with the measuring points. The universal standard functions only work with the standard interfaces 3-phase current and/or 3-phase voltage; the other 4 interfaces are provided for the functions which are exclusively used for the capacitor banks. Please also refer to the example given below.

The Capacitor bank function group has the following interfaces with the measuring points:

- 3-phase current:
  The measurands from the 3-phase current system are supplied via this interface. Depending on the connection type of the current transformers, the measurands can be for example I_A, I_B, I_C, I_N, or $3I_0$. All values that can be calculated from the measurands are also provided via this interface.
  The **Capacitor bank** function group must always be connected to the 3-phase current measuring point. You can connect the 3-phase current measuring point interface to the maximum of two 3-phase current measuring points. If 2 current measuring points have been connected to the 3-phase current interface, the total current is determined by adding the measured values from both measuring points in the function group. The functions in the **Capacitor bank** function group evaluate the total current.
- 3-phase voltage (optional):
  The measurands from the 3-phase voltage system are supplied via this interface. Depending on the connection type of the voltage transformers, these can be for example V_A, V_B, V_C, V_N or $3V_0$. All values that can be calculated from the measurands are also provided via this interface.
  The connection of the 3-phase voltage interface is optional. This connection is only required if protection functions or supervision functions are applied, which require voltage measurements.
- 3-phase voltage CB tap (optional):
  The measurands of a 3-phase tap voltage within a capacitor bank are supplied via this interface.
  The connection of the 3-phase voltage CB tap interface is optional. You can connect the 3-phase voltage CB tap interface to a maximum of one 3-phase voltage measuring point.
- Voltage unbalance (optional):
  The unbalanced-voltage measurands (for example, an isolated neutral point of the capacitor bank) are supplied via this interface.
  The connection of the voltage unbalance interface is optional. You can connect the voltage unbalance interface to a maximum of one 1-phase voltage measuring points.
- Current unbalance (optional):
  The unbalanced-current measurands are supplied via this interface.
  The connection of the current unbalance interface is optional. You can connect the current unbalance interface to a maximum of two 3-phase current measuring points and six 1-phase current measuring points. The interface allows mixed connections to 3-phase current measuring point and 1-phase current measuring point; however the sum of the connections is no more than 6.
  For an overview which function are applicable on this interface, please refer to Figure 1-5.
- 3-phase current RLC (optional)
  The measurands from a tuning or filtering section (R, L, or C) of a capacitor bank are supplied via this interface.
  The connection of the 3-phase current RLC interface is optional. You can connect the 3-phase current RLC interface to a maximum of one 3-phase current measuring points.
  For an overview which function are applicable on this interface, please refer to Figure 5-13.

Example

The following figure shows an example of a capacitor in H-configuration and tuning section. In the single line, the primary current and voltage measurement are shown. The required device measuring points and their connections to the function group interfaces are shown as well. In addition, it is indicated which protection function receives its measuring value from which measuring point.

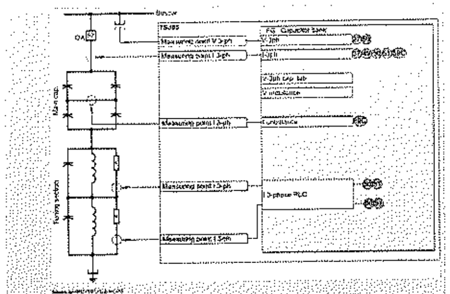


Figure 5-13 An Example of Assignment of Measuring Points to the Capacitor Bank Functions

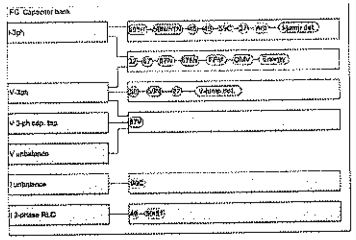
You can connect the **Capacitor bank** function group to the current and voltage measuring points via interfaces. You make this assignment in DIGSI via **Project tree → Function group connections**. To connect the interfaces, set a cross at the intersection between the row and column in the matrix.

Figure 5-14 Connecting Measuring Points to the Capacitor Bank Function Group

For the protection functions applied on the interfaces **3-phase current** and **3-phase voltage**, if you add these functions to the **Capacitor bank** function group, these functions will automatically receive the measured values from the correct measuring points. If you add protection functions to the function group but the necessary interface is not connected to any measuring point, DIGSI 5 reports an inconsistency. Configure the measuring points in DIGSI 5 using the **Function group connections** editor.

For the protection functions applied on the interfaces **Current unbalance** and **3-phase current**, you have to select the desired measuring points via a setting `MP selection`, which offers a list of all measuring points connected to the specific interface. The setting `MP selection` is located on the setting page of the protection function.

The following figure shows an overview of the protection functions and the interface assignment in the **Capacitor bank** function group.



27	Undervoltage protection
32	General power protection
37	Undercurrent protection
46	Negative-sequence protection
49	Overload protection
50/51	Overcurrent protection, phases
50N/51N	Overcurrent protection, ground
59	Overvoltage protection
59C	Peak overvoltage protection
59N	Overvoltage protection with zero-sequence voltage/residual voltage
60C	Current-unbalance protection
67/67N	Directional overcurrent protection for ground faults
67Ns	Directional sensitive ground-fault detection
87V	Voltage-differential protection
OMV	Operational values
FFM	Fuse-failure monitor

Figure 5-15 Overview of the Protection Functions and Interface Assignment in the Capacitor Bank Function Group

Interfaces with Circuit-Breaker Function Group

All required data are exchanged between the protection function group and the Circuit-breaker function group via the interface with the **Circuit-breaker** function group. These data include, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for another example, the information about the circuit-breaker condition sent in the direction of the protection function group.

The **Capacitor bank** function group is connectable to a **Circuit-breaker** function group. This connection generally determines:

- Which circuit breaker is activated by the protection functions of the **Capacitor bank** function group
- Starting of the **Circuit-breaker failure protection** function (if available in the Circuit-breaker function group) through the protection functions of the connected **Capacitor bank** function group
- Starting of the **Automatic reclosing** function (if available in the Circuit-breaker function group) through the protection functions of the connected **Capacitor bank** function group

NOTE

For capacitor bank protection, the Automatic reclosing function is not applied in most cases. However, due to flexibility and standardization, the respective interface is offered.

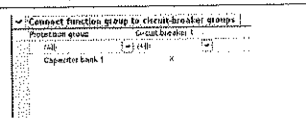


Figure 5-16 Connecting Capacitor Bank Function Group with Circuit-Breaker Function Group

Besides the general assignment of the **Capacitor bank** function group to the Circuit-breaker function group, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit breaker interaction** editor in the Capacitor bank function group.

In the detailed configuration of the interface, define:

- Which operate indications of the protection functions go into the generation of the trip command
- Which protection functions start the **Circuit-breaker failure protection** function
- Which protection functions start the **Automatic reclosing** function

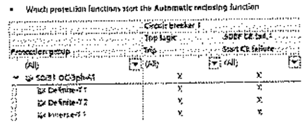


Figure 5-17 Connecting Protection Functions and Stage Using the Circuit-Breaker Interaction Editor

If an application template is used, the function groups have already been connected to each other because this link is essential to ensure proper operation. You can modify the link in DIGSI 5 using the **Function-group connections** editor.

You can find more information in chapter 2.1 *Function Embedding in the Device*. If this link is missing, DIGSI 5 reports an inconsistency.

Protected Object/Equipment Data (FB General)

Capacitor-bank rated and reference data are defined as well as further protected object/equipment data. The data applies for all functions in the **Capacitor bank** function group.

For further information, refer to chapter 5.4.3 *Application and Setting Notes*.

Capacitor Bank Device Status and Blocking by Discharging (FB General)

The functionality detects whether a capacitor bank is online or offline. When the status of the capacitor bank changes from online to offline, the signal *Discharge* is issued during the capacitor bank discharging time.

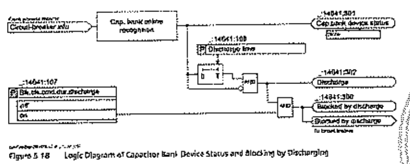


Figure 5-18 Logic Diagram of Capacitor Bank Device Status and Blocking by Discharging

The device can block the closing of the circuit breaker automatically when a capacitor bank discharges. The configuration is made with the parameter `Blk. cls. cmd. dur. discharge`. If the parameter `Blk. cls. cmd. dur. discharge` is set to on, the device generates a trip/open command during the discharge time and blocks closing commands additionally, see the following figure. This blocking condition is signaled via the message *Blocked by discharge*.

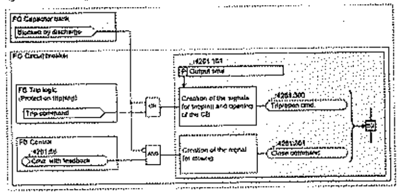


Figure 5-19 Logic Diagram of Processing the Blocked by Discharge Signal

Global Compensation (FB General)

The **Global compensation** function block provides the binary input signal *>Compensate* to carry out the manual compensation for all functions in the FG using compensated measuring values.

In addition, the binary input signal *>Reset comp. val.* is provided to reset all compensation values for the functions using compensated measuring values.

Process Monitor

The **Process monitor** detects the current state of the protected object. It is always present in the function group and cannot be removed.

For detailed description of the **Process monitor**, refer to 5.8.1 *Overview of Functions*.

Reset LED Group

The **Reset LED group** function block allows you to reset only the stored LEDs of the functions contained in the respective function group, while stored LEDs activated from functions in other function groups remain active.

For more information refer to chapter 3.1.10 *Resetting Stored Indications of the Function Group*.

Operational, Fundamental, Symmetrical Components Measurements

The operational fundamental, symmetrical components and functional measurements are always available in the **Capacitor bank** function group and cannot be deleted.

Table 5-4 Operational Measured Values (True RMS) of the Function Group Capacitor Bank

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
I_N	Neutral-point phase current	A	A	Rated operating current of the primary system
$3I_0$	Residual 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 voltage	kV	V	Rated operating voltage of the primary system
V_0	Zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_{NG}	Neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3
f	Frequency	Hz	Hz	Rated frequency
P_{total}	Active power (total power)	MW	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{total}	Reactive power (total power)	MVAr	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	–	Rated operating voltage and rated operating current of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	–	Apparent power of the phase $V_{rated,ph} \cdot I_{rated,ph}$
Q_A, Q_B, Q_C	Phase-related reactive power	MVAr	–	Apparent 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 $V_{rated,ph} \cdot I_{rated,ph}$

Table 5-5 Fundamental and Symmetrical Components Measurement Values of the Function Group Capacitor Bank

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system

Measured Values		Primary	Secondary	% Referenced to
I_N	Neutral-point phase current	A	A	Rated operating current of the primary system
I_{seq0}	Zero-sequence current	A	A	Rated operating current of the primary system
I_{seq1}	Positive-sequence current	A	A	Rated operating current of the primary system
I_{seq2}	Negative-sequence current	A	A	Rated operating voltage of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary system
V_N	Neutral point phase voltage	kV	V	Rated operating voltage of the primary system/√3
V_{seq0}	Zero-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_{seq1}	Positive-sequence voltage	kV	V	Rated operating voltage of the primary system/√3
V_{seq2}	Negative-sequence voltage	kV	V	Rated operating voltage of the primary system/√3

Voltage and power measurements are only available if **V-3ph** measuring point connected to the **Capacitor bank** function group.

The energy measurements are not predefined. If required, they must be loaded from the Global DIGSI 5 Library.

Inversion of Power-Related Measured and Statistical Values (FB General)

The following values calculated in operational measured values are defined positively in the direction of the protected object.

- Power
- Power factor
- Energy
- Minimum, maximum values of the power
- Average values of the power

With the **P, Q sign** setting, you can invert the sign of these operational measured values such that a power flow from the line to the busbar is displayed positively.

More information can be found in Chapter 10.1 *Overview of Functions*.

Output Logic

The output logic treats the pickup and operate indications of the protection functions and supervision functions in the **Capacitor bank** function group separately, in a pickup logic and an output logic respectively. The pickup and output logics generate the group indications of the function group. These group indications are transferred to the **Circuit-breaker** function group via the protection-information interface and are processed further there.

The pickup and operate indications of the protection functions and the supervision functions in the **Capacitor bank** function group are combined according to the following figures of group indications.

ВЯРНО С ОРИГИНАЛА

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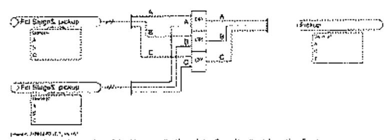

Figure 5-20 Generation of the Pickup Indication of the Capacitor Bank Function Group

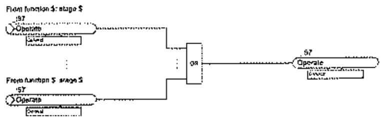

Figure 5-21 Generation of the Operate Indication of the Capacitor Bank Function Group

5.4.3 Application and Setting Notes

Interface to Circuit-Breaker Function Group

The **Capacitor bank** protection function group is linked to one **Circuit-breaker** function group. This **Circuit-breaker** function group is assigned to the circuit breaker of the capacitor bank.

Protected Object/Equipment Data (FB General)

The following application and setting notes apply for the general data. The data are configured in the function block **General** of the **Capacitor bank** function group and apply for all functions in the function group.

Parameter: Capacitor reference curr.

- Default setting (_:14641:101) Capacitor reference curr. = 1000 A

With the Capacitor reference curr. parameter, you set the reference current for the capacitor bank to be protected. This Capacitor reference curr. specified here is the reference value for the percentage-measured values and setting values made in percentages.

Depending on the user philosophy, the reference value could be the capacitor-bank rated current, which includes harmonics, or the capacitor-bank fundamental current.

Parameter: Capacitor reference volt.

- Default setting (_:14641:102) Capacitor reference volt. = 400.00 kV

With the parameter Capacitor reference volt., you set the reference voltage of the capacitor bank to be protected. This Capacitor reference volt. specified here is the reference value for the percentage-measured values and setting values made in percentages.

Depending on the user philosophy, the reference value could be the system rated voltage (bus voltage), or the capacitor rated voltage.

Parameter: Capacitor element type

- Default setting (_:14641:106) Capacitor element type = fused

With the parameter Capacitor element type, you set if the capacitor elements contain internal fuses or not. This information is required in the current-unbalance protection for the fault position annunciation.

Parameter: Blk. cls. cmd. dur. discharge

- Default setting (_:14641:107) Blk. cls. cmd. dur. discharge = off

With the parameter Blk. cls. cmd. dur. discharge, you set whether closing of the circuit breaker is blocked automatically or not when a capacitor bank discharges.

NOTE

If the parameter Blk. cls. cmd. dur. discharge is set to on, the device generates a trip/open command during the discharge time.

Parameter: Discharge time

- Default setting (_:14641:108) Discharge time = 300 s

With the parameter Discharge time, you define capacitor-bank discharging duration. You get the value from the capacitor manufacturer.

Parameter: Cap.-bank neutral point

- Default setting (_:14641:109) Cap.-bank neutral point = isolated

With the parameter Cap.-bank neutral point, you can specify whether the neutral point of capacitor bank is isolated or grounded. This information is required when applying the function 87V voltage differential protection.

Parameter: P, Q sign

- Default setting (_:14611:158) P, Q sign = not reversed

The power and energy values are defined by the manufacturer such that power in the direction of the protected object is considered positive. You can also define the power output by the protected object as positive. With the P, Q sign parameter, you can invert the sign for these components. This inversion does not influence any protection function.

5.4.4 Write-Protected Settings

The settings listed here are primarily to aid understanding when configuring the function groups. They are calculated as a function of other settings and cannot be changed directly.

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:14641:103	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA

NOTE

You can find more detailed information on the Process monitor in Chapter 5.7.1 Overview.

5.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:14641:101	General:Capacitor reference curr.		1 A to 100000 A	1000 A
_:14641:102	General:Capacitor reference volt.		0.20 kV to 1200.00 kV	400.00 kV
Cap.bank data				
_:14641:106	General:Capacitor element type		• fused • unfused	fused
_:14641:107	General:Blk.cls.cmd.dur. discharge		• off • on	off
_:14641:108	General:Discharge time		1 s to 1200 s	300 s
_:14641:109	General:Cap. bank neutral point		• grounded • isolated	isolated
Measurements				
_:14611:158	Further settings:P, Q sign		• not reversed • reversed	not reversed

5.4.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O
General			
_:14641:500	General:>Compensate	SPS	I
_:14641:501	General:>Reset comp. val.	SPS	I
_:14641:300	General:Blocked by discharge	SPS	O
_:14641:302	General:Discharge	SPS	O
_:14641:301	General:Cap.bank device status	SPC	C

5.5 Function-Group Type Capacitor Bank Differential Protection

5.5.1 Function-Group Types

In the following graphic, you can see the structural association of the function-group types to the Capacitor bank differential protection.

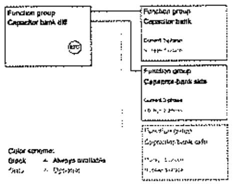

Figure 5-22 Function-Group Types Capacitor Bank Diff

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

- **Capacitor bank diff**
- **Capacitor bank side**

You can find the description of the function group **Capacitor bank** in chapter 5.4.1 Overview.

The individual function-group types are stored in the **Capacitor bank diff** function group folder and can be selected. In the protection function folders, you find all protection functions which are operational in each function group. A **Capacitor bank diff** function group always includes the **Capacitor bank** and **Capacitor bank side** function groups. In total, you can assign a maximum of 3 function groups **Capacitor bank** or **Capacitor bank side** to the **Capacitor bank diff** function group.

The following table shows you the number of function-group types that can be instantiated for device 7SJ85.

Table 5-6 Function-Group Types in the Device

Device	Function-Group Type		
	Capacitor Bank Diff	Capacitor Bank	Capacitor Bank Side
7SJ85	Max. 2	Max. 9	Max. 9

Interconnection of the function groups is necessary so that the capacitor bank differential protection functions properly. The **Circuit-breaker** function group is not listed.

Table 5-7 Assignment of Protection Function Groups to Protection Function Groups

	Capacitor Bank Diff 1
	Side (2 to 3)
Capacitor bank	X
Capacitor bank side 1	X
Capacitor bank side 2	X

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

5.5.2 Function-Group Type Capacitor Bank Diff

5.5.2.1 Overview

The **Capacitor bank diff.** function group contains the differential protection function and protection function-relevant measured values.

You can find more information in the chapter 10 *Measured Values, Energy Values, and Supervision of the Primary System*.

You will find the corresponding function groups and the folders with the usable protection functions in the Global DIGSI library under each device type. In the **Capacitor bank diff.** function group, you can load only the differential protection functions.

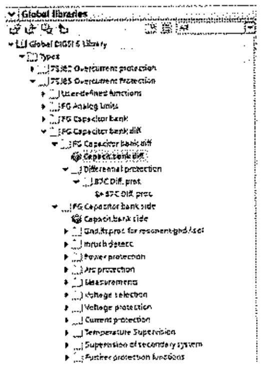

Figure 5-23 Function Group Capacitor Bank Diff. - Functional Scope

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

5.5.2.2 Structure of the Function Group

The **Capacitor bank diff.** function group, according to 5.5.2.1 Overview, has interfaces with the **Capacitor Bank**, the **Capacitor bank side**, and the **Circuit-breaker** function groups. The **Capacitor bank diff.** function group contains the function blocks:

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

In the **Capacitor bank diff.** function group, the differential protection function must always be available so that the protection functionality can be ensured. If you do not use an application template, load the differential protection function from the Global DIGSI library.

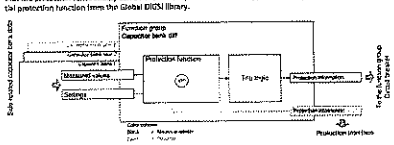

Figure 5-24 Structure of the Capacitor Bank Diff. Function Group

The **Capacitor bank diff.** function group has interfaces to the following components:

- Function group **Capacitor bank**
- Function group **Capacitor bank side**
- **Circuit-breaker** function group

Interfaces with the Circuit-Breaker Function Group

The interface with the **Circuit-breaker** function group is used to exchange all required data between the protection function group and the **Circuit-breaker** function group. The following data is required:

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

You can connect the **Capacitor bank diff.** function group to one or more **Circuit-breaker** function groups. This connection determines the following:

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

Besides the general assignment of the **Capacitor bank diff.** function group to the **Circuit-breaker** function group, you can also configure the interface for specific functionalities in detail. Configure the details in DIGSI 5 via the **Circuit-breaker** Interaction Editor in the **Capacitor bank side diff.** function group.

For the detail configuration of the interface, define the following:

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

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

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

Resetting the LED Group

Using the Reset the LED group function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Interface with Protection Communication (optional)

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

- Binary signals
- Measured values
- Complex data

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

Capacitor-Bank Data (General)

The capacitor-bank data characterizes the data of the capacitor bank to be protected. The data relevant for the differential protection is shown. The **Capacitor bank diff.** function group takes the data from the coupled function groups **Capacitor bank** and **Capacitor bank side.**

Output Logic

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

The pickup and operate indications of the protection and supervision functions in the **Capacitor bank diff.** function group are combined into one group indication using the following numbers and outputs.

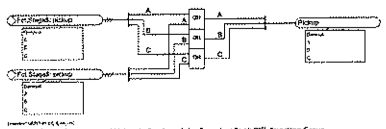

Figure 5-25 Generation of Pickup Indication of the Capacitor Bank Diff. Function Group

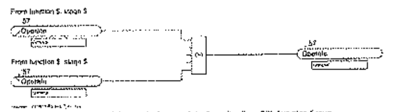

Figure 5-26 Generation of Operate Indication of the Capacitor Bank Diff. Function Group

5.5.2.3 Information List

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

5.5.3 Function-Group Type Capacitor Bank Side

5.5.3.1 Overview

In the **Capacitor bank side** function group, all of the functions that are necessary for protecting and supervising a capacitor bank side can be used. The **Capacitor bank side** function group also contains the measuring functions.

You can find more information in chapter 9.1 *Measured Values, Energy Values, and Supervision of the Primary System*.

The **Capacitor bank side** function group must always have interfacing to the **Capacitor bank diff.** function group.

You will find the corresponding function groups and the folders with the usable protection functions in the Global DIGSI library under each device type. Depending on the connected measuring points, you can load the respective protection and supervision functions in the **Capacitor bank side** function group. The functions are described in chapter 6 *Protection and Automation Functions*.

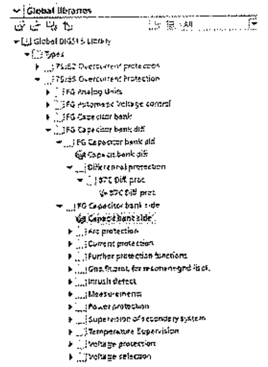

Figure 5-27 Capacitor Bank Side Function Group - Functional Scope

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

5.5.3.2 Structure of the Function Group

The **Capacitor bank side** function group always contains the following function blocks:

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

These blocks are required for the **Capacitor bank side** function group and therefore cannot be loaded or deleted.

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

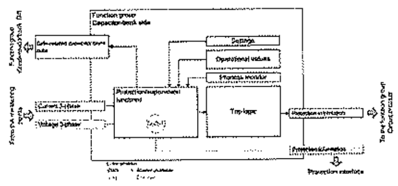

Figure 5-28 Structure of the Capacitor Bank Side Function Group

The **Capacitor bank side** function group has interfaces to the following components:

- **Measuring points**
- **Capacitor bank diff.** function group
- **Circuit-breaker** function group

Interfaces with Measuring Points

The **Capacitor bank side** function group receives the required measured values via its interfaces with the measuring points. If you are using an application template, the **Capacitor bank side** function group is connected to the necessary measuring points.

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

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

The **Capacitor bank side** function group has the following interfaces with the measuring points:

- 3-phase current

  The measurands from the 3-phase power system are supplied via this interface. Depending on the transformer connection type, these are for example I_A, I_B, I_C, or $3I_0$. All values that can be calculated from the measurands are also provided via this interface. The **Capacitor bank side** function group must always be linked to the I-3ph measuring point.

  You can connect the **3-phase current** interface with a maximum of two 3-phase current measuring points. If 2 current measuring points have been connected to the **3-phase current** interface, the total current is also determined from measured values from both measuring points in the **Capacitor bank side** function group. All functions in the **Capacitor bank side** function group have access to these values.

- 3-phase voltage (optional):

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

  The connection of the 3-phase voltage is optional. This connection is necessary only if protection or supervision functions that require voltage measurements are used.

Interfaces to the Circuit-Breaker Function Group

The interface with the **Circuit-breaker** function group is used to exchange all required data between the protection function group and the **Circuit-breaker** function group. The following data is required:

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

You can connect the **Capacitor bank side** function group to one or more **Circuit-breaker** function groups. This connection determines the following:

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

Besides the general assignment of the **Capacitor bank side** function group to the **Circuit-breaker** function group, you can also configure the interface for certain functionalities in detail. Configure the details in DIGSI 5 using the **Circuit-breaker interaction** Editor in the **Capacitor bank side** function group.

For the detail configuration of the interface, define the following:

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

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

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

Interface with Protection Communication (optional)

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

- Binary signals
- Measured values
- Complex data

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

Resetting the LED Group

Using the **Reset the LED group** function, you can reset the stored LEDs of the functions in one specific function group while the activated, stored LEDs of other functions in other function groups remain activated.

Process Monitor

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

- Current-flow criterion:

  Detection of an open/activated capacitor bank side based on the flow of leakage current
- Closure detection:

  Detection of closure of the capacitor bank side
- Cold-load pickup detection (optional):

This information is in the **Capacitor bank side** function group and is available to all the functions in the function group.

Operational Measured Values

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

Table 5-8 Possible Operational Measured Values of the Capacitor Bank Side Function Group

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

If a V-3ph measuring point was connected to the **Capacitor bank side** function group, voltage and phase measurements are available.

The energy measurements are not predefined. If necessary, you must load them from the Global DIGSI 5 library.

Depending on the protection and supervision functions used, additional function measurements may be available. The function values are listed in the Information list of the appropriate protection or supervision function (see chapter 6 *Protection and Automation Functions*).

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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 Power-Related Measured and Statistical Values):

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase related): Q_A, Q_B, Q_C

Capacitor-Bank Data (Side-Dependent)

The capacitor-bank data characterizes the data of the capacitor bank to be protected. The side-dependent capacitor-bank data applies to all of the functions in the **Capacitor bank side** function group.

Output Logic

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

The pickup and operate indications of the protection and supervision functions in the **Capacitor bank side** function group are combined into one group indication using the following numbers and outputs:

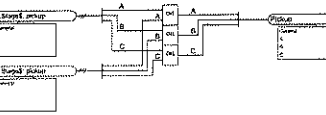

Figure 5-29 Generation of Pickup Indication of the Capacitor Bank Side Function Group

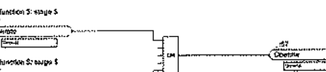

Figure 5-30 Generation of Operate Indication of the Capacitor Bank Side Function Group

5.5.3.3 Application and Setting Notes

Interface to the Circuit-Breaker Function Group

The **Capacitor bank side** function group is usually connected to 1 Circuit-breaker function group. The **Circuit-breaker** function group is assigned to the circuit breaker of the capacitor bank.

Parameter: Rated apparent power

- Default setting (_:1781:15571:103) Rated apparent power = 692.82 MVA

The Rated apparent power parameter shows the primary rated apparent power of the capacitor bank to be protected. The setting value is determined of the Capacitor reference volt. and the Capacitor reference curr. parameters.

Parameter: Capacitor reference volt.

- Default setting (_:1781:15571:102) Capacitor reference volt. = 400.00 kV

You can use the Capacitor reference volt. parameter to set the reference voltage of the capacitor bank to be protected. The reference voltage set here is the reference value for the percentage measured values and setting values made in percent.

Depending on user philosophy you can use the system rated voltage (busbar voltage) or the capacitor rated voltage as a reference value.

Parameter: Capacitor reference curr.

- Default setting (_:1781:15571:101) Capacitor reference curr. = 1000 A

You can use the Capacitor reference curr. parameter to set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and setting values in percent.

For Differential protection, these values are used for absolute-value correction (rated current of the protected object).

If the capacitor bank is part of a delta connection, the value to be set here can differ from the capacitor reference current set in the **Capacitor bank** function group (by factor √3). Otherwise, set always the same values.

Depending on user philosophy, you can use the capacitor-bank rated current including the harmonics or the capacitor-bank fundamental-component current as a reference value.

Parameter: Neutral point

- Default setting (_:1781:15571:149) Neutral point = isolated

With the Neutral point parameter, you specify whether the neutral point in the protection range of the differential protection is grounded or isolated. If there is no neutral point in the protection zone, use the parameter isolated. The neutral point of a capacitor bank is usually not in the protection zone. Therefore, even if the neutral point is grounded, set isolated here.

You can find further information in the Device manual 7UT8 Chapter 6.2.3 function description neutral point current handling.

Parameter: Winding configuration

- Default setting (_:1781:15571:104) Winding configuration = Y (Wye)

You can use the Winding configuration parameter to set D (Delta) for a delta connection. Another setting option is Y (Wye) for a star connection. The Winding configuration parameter is relevant for the Differential protection function.

Parameter: Vector group numeral

- Default setting (_:1781:15571:100) Vector group numeral = 0

This parameter is used to account for phase angle rotation, which is expressed by a numeral.

Phase-angle rotation	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Vector group numeral	0	1	2	3	4	5	6	7	8	9	10	11

In the function group, the following information is displayed additionally in the setting sheet:

- Side number
- Identification of the measuring points used
- Adaptation factor for the 3-phase measuring point (with reference to the side)

Each Vector group numeral can be set from 0 to 11 to the extent possible. Thus, for example, only even numbers are possible for the vector group Yy and Dd and only odd numbers are possible for Yd and Dy.

Parameter: Side number

- Default setting (_:1781:14611:130) Side number = not assigned

The Side number parameter shows you which capacitor bank side is currently valid for the following parameters. The side number (Side 1 to Side 3) is automatically assigned with the connection to a capacitor bank side.

Parameter: MI3ph1 usesMeasP with ID

- Default setting (_:1781:14611:210) MI3ph1 usesMeasP with ID = 0

The MI3ph1 usesMeasP with ID parameter shows you which 3-phase measuring point is connected to the capacitor bank side. Every measuring point is assigned a unique ID.

Parameter: MI3ph2 usesMeasP with ID

- Default setting (_:1781:14611:211) MI3ph2 usesMeasP with ID = 0

The MI3ph2 usesMeasP with ID parameter shows you which 3-phase measuring point is connected to the capacitor bank side. Every measuring point is assigned a unique ID.

Parameter: CT mismatch M I-3ph 1

- Default setting (_:1781:14611:215) CT mismatch M I-3ph 1 = 0.000

The CT mismatch M I-3ph 1 parameter shows you the magnitude adaptation of the phase currents of the 1st assigned measuring point. The numerical value results from the ratio of the primary rated current of the current transformer to the rated current of the side.

Parameter: CT mismatch M I-3ph 2

- Default setting (_:1781:14611:217) CT mismatch M I-3ph 2 = 0.000

The CT mismatch M I-3ph 2 parameter shows you the magnitude adaptation of the phase currents of the 2nd assigned measuring point.

5.5.3.4 Write-Protected Settings

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

Addr.	Parameter	C	Range of Values	Default Setting
Rated values				
_:1781:15571:103	Rated apparent power		0.20 MVA to 5000.00 MVA	692.82 MVA

Addr.	Parameter	C	Range of Values	Default Setting
Side data				
_:1781:14611:130	Side number		• not assigned • Side 1 • Side 2 • Side 3	Side 2
_:1781:14611:210	MI3ph1 usesMeasP with ID		0 to 100	8
_:1781:14611:215	CT mismatch M I-3ph 1		0.010 to 100.000	1.000

5.5.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Rated values				
_:1781:15571:101	General:Capacitor reference curr.		1 A to 100 000 A	1000A
_:1781:15571:102	General:Capacitor reference volt.		0.20 kV to 1200.00 kV	400.00 kV
Side data				
_:1781:15571:149	General:Neutral point		• grounded • isolated	isolated
_:1781:15571:104	General:Winding configuration		• Y (Wye) • D (Delta)	Y (Wye)
_:1781:15571:100	General:Vector group numeral		0 to 11	0
Measurements				
_:1781:14611:158	Further settings:P, Q sign		• not reversed • reversed	not reversed

5.5.3.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Reset LED Group			
_:7381:500	Reset LED Group:>LED reset	SPS	I
_:7381:320	Reset LED Group:LED have been reset	SPS	O

5.6 Function-Group Type Analog Units

5.6.1 Overview

The **Analog units** function group is used to map analog units and communicate with them. Analog units are external devices, such as RTD units, or analog plug-in modules, such as measuring-transducer modules.

You will find the **Analog units** function group for many device types in the Global DIGSI 5 library.

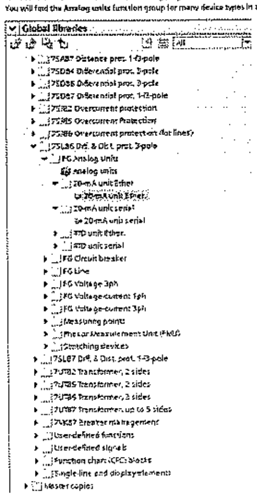

Figure 5-31 Analog Unit Function Group in DIGSI

5.6.2 Structure of the Function Group

If the device has a measuring transducer, it is automatically mapped in the **Analog units** function group. If one or more RTD units are connected to the device, you have to load one or more **RTD unit Ether.** or **RTD unit serial** functions from the Global DIGSI library in order to map the RTD units.

The following figure shows the structure of the function group.

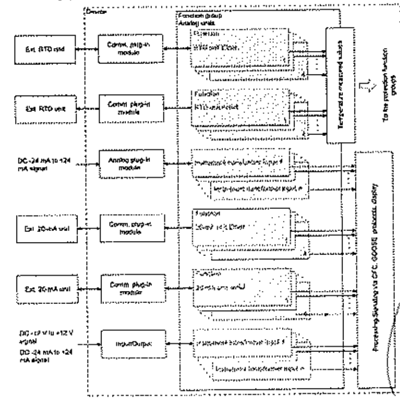

Figure 5-32 Structure of the Analog Unit Function Group

The **Analog units** function group has interfaces to protection function groups. The **Analog units** function group provides measured temperature values that come from an external RTD unit. These measured temperature values are available for all protection function groups in which a temperature monitoring function works.

The **RTD unit Ether.** function is not preconfigured by the manufacturer. A maximum of 20 function instances can work simultaneously.

The **RTD unit serial** function is set up structurally exactly in the same manner as the **RTD unit Ether.** function.

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5.6.3 20-mA Unit Ethernet

5.6.3.1 Overview

The function 20-mA unit Ether.:

- Communicates in series with a 20-mA unit via the Slave Unit Protocol (SUP) and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process tags such as temperature or gas pressure
- Makes the recorded process tags available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

5.6.3.2 Structure of the Function

The function 20-mA unit Ether. can work only in the function group Analog units. A maximum of 4 function instances can work simultaneously. Each instance contains 12 preconfigured channel function blocks.

The function 20-mA unit Ether. contains input and output channels which can be configured independently of one another.

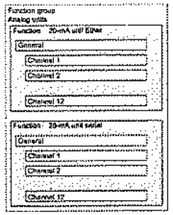

Figure 5-33 Structure/Embedding of the Function

5.6.3.3 Communication with 20-mA Unit Ethernet

Logic

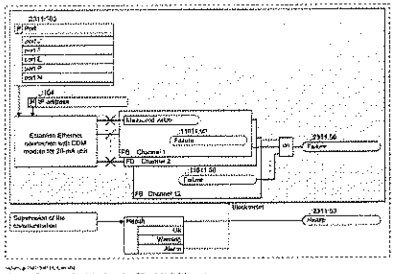

Figure 5-34 Logic of the Function 20-mA Unit Ethernet

Communication with 20-mA Unit

The function is used to communicate with a 20-mA unit connected via an Ethernet connection. When a connection of the function to an external 20 mA unit via an Ethernet interface has successfully been established, the 20-mA unit sends the measured values of all connected channels to the function 20-mA unit. Ether.. For the connection to be established successfully, specific communication settings must be specified. You can find more detailed information in Chapter 5.6.3.4 *Application and Setting Notes*.

The 20-mA measurement unit 7XV5674 is supported.

Error Responses

The following table lists the conditions under which the *Health* status transitions to the Alarm or Warning state.

Table 5-9 Error Responses

Error Description	Status Health
The function 20-mA unit Ether. cannot establish a connection with a communication module.	Alarm
The function 20-mA unit Ether. sends TCP settings to the communication module, which evidently would like to connect to the 20-mA unit via a serial protocol. This communication module does not establish a connection to the 20-mA unit.	Alarm
The connection between the communication module and the 20-mA unit causes a time-out indication.	Warning

Error Description	Status Health
A communication module has not received any more data from the 20-mA unit for 9 sec.	Warning

The *Failure* signal is set as soon as one of the channel function blocks reports a failure.

5.6.3.4 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = port J

Use the Port setting to define the port connecting the 20 mA unit to the SIPROTEC 5 device.

Parameter: IP address

- Default setting (_:2311:104) IP address = 10.16.60.1

With the IP address settings, you set the IP address of the 20-mA unit connected to the communication module via the TCP protocol. You must assign each 20-mA unit an unambiguous IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. First set an IP address for the 7XV5674 20-mA unit. Then specify the IP address settings for the communication module to the same address.

Settings on the 20-mA Unit

The 7XV5674 20-mA unit is set with a web browser on the laptop computer via the latter's Ethernet interface. Set Modbus TCP as bus protocol/operating mode.

You can find detailed notes on the settings in the 7XV5674 manual that accompanies the 20-mA unit. The documents are also available in the SIPROTEC download area http://www.energy.siemens.com.

5.6.3.5 20-mA Channel

Logic

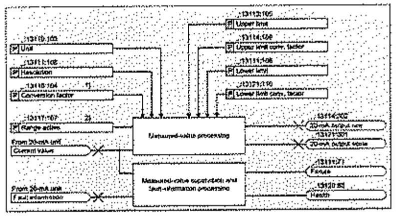

Figure 5-35 Logic Diagram of the Function 20-mA Channel

(1) If the setting Range active is set to true, the setting Transformation ratio is not displayed.

(2) If the setting Range active is set to false, the settings Upper limit, Transformation ratio upper limit, Lower limit and Transformation ratio are not displayed.

Measured-Value Calculation

The function 20-mA channel processes a single 20-mA current signal supplied by the 20 mA unit of the corresponding channel. The 20-mA current measured value is converted into the correct physical quantities such as temperature or pressure. In each 20-mA functional unit (Ether. and serial) there are always 12 of the 20-mA channel function blocks, even if fewer channels are connected with the 20-mA unit. The calculated values are available for further processing via CFC, GOOSE, protocols, and the display image.

Measured-Value Processing

The 20-mA unit typically transmits a value which represents a physical quantity, such as a temperature or a pressure. Therefore, the device must contain a characteristic curve that maps the physical quantity to the 20 mA value. If you do not activate the Range active setting (no x in the check box), the function operates over the range 0 mA to 20 mA. If a value smaller than 0 mA or greater than 20 mA is active at the input of the 20-mA unit, the measured value is identified as invalid. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA. The following figure shows an example.

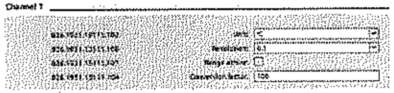

Figure 5-36 Settings for Example 1

In this example, the measured value 0 mA means a temperature of 0 °C and the measured value 20 mA means a temperature of 100 °C. So enter as Unit = °C and Conversion factor = 100. The resolution (decimal place) of the temperature value can be chosen: for a decimal place, select Resolution = 0.1.

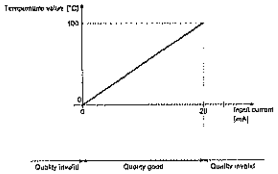

Figure 5-37 Characteristic Curve of a 20-mA Input (Example 1)

If you activate the Range active setting, then 4 additional parameters Upper limit, Lower limit, Upper limit - Sensor, and Lower limit - Sensor appear. The parameters Upper limit and Lower limit indicate the range of the input current in mA. The setting Upper limit - Sensor is the calculated measured value if the input current corresponds to the value in the Upper limit setting. The setting Lower limit - Sensor is the calculated measured value if the input current corresponds to the value in the Lower limit setting. The setting of the range for the scaled value corresponds to the usable range between Lower limit and Upper limit (see following figure).

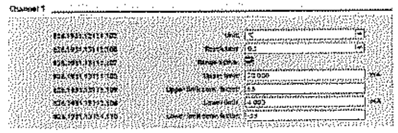

Figure 5-38 Settings for Example 2

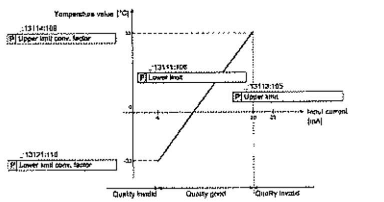

Figure 5-39 Characteristic Curve of a 20-mA Unit (Example 2)

In this example, the Range active setting is selected. The setting Upper limit is at 20 mA, the setting Lower limit is at 4 mA. The setting Upper limit - Sensor is at 55 and the setting Lower limit - Sensor is at -33. If the input current is smaller than 4 mA or greater than 20 mA, the quality of the scaled measured value in this example is invalid.

Each 20-mA channel makes available the scaled measured value in the information routing (these are the temperature values in the examples) and the original current measured value in mA for further processing. The 20-mA values can be displayed in the display page and processed with CFC charts.

Error Responses

If the current input value is determined to be incorrect, the quality attribute of the output value is set to *invalid* for that status for *Health* and the defect status assume the states displayed in the table

Table 5-10 Error Responses

Error Description	Status *Health*	Error Status
The input value lies outside the given limits	OK	Yes
Channel not connected	OK	No

5.6.3.6 Application and Setting Notes

Parameter: Unit

- Default setting (_:13111:100) Unit = °C

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

Parameter: Conversion factor

- Default setting (_:13111:104) Conversion factor = 100

The Conversion factor setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting (_:13111:100) Resolution = 0.1

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

Parameter: Range active

- Default setting (_:13111:107) Range active = false

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

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

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

- Default setting (_:13111:105) Upper limit = 20000 mA
- Default setting (_:13111:109) Upper limit - Sensor = 100
- Default setting (_:13111:106) Lower limit = 4000 mA
- Default setting (_:13111:110) Lower limit - Sensor = 100

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

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

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5.6.3.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
Channel 1				
_:13111:103	Channel 1:Unit		• % • - • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • Ws • Wh	m
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-10000 to 10000	100

5.6.3.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.6.4 20-mA Unit Serial

5.6.4.1 Overview

The function 20-mA unit Serial:

- Provides serial communication with a 20-mA unit via the Modbus protocol and records the values measured by the 20-mA unit
- Transforms the measured 20-mA values into slowly changing process variables such as temperature or gas pressure
- Makes the recorded process values available to CFC, GOOSE, protocols and the device display
- Monitors communication with the 20-mA unit

The function 20-mA Unit Serial is structured in the same way as the function 20-mA Unit Ether. The mode of operation is also identical. The only difference is that the measured values are transferred to the communication module via a serial connection instead of an Ethernet connection.

You can find more information in Chapter 5.6.3.2 Structure of the Function.

5.6.4.2 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = Port J

With the Port setting, you specify the slot for the communication module that will be used for the connection with an external 20-mA unit.

Parameter: Channel number

- Default setting (_:2311:105) Channel number = 1

A serial communication module optionally uses 2 channels. With the Channel number setting, you specify the channel number (1 or 2) used to connect the 20-mA unit to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting (_:2311:106) Slave address = 1

Use the Slave address setting to define the device address of the 20-mA unit. If only one 20-mA unit is connected to the serial bus, the default value 1 can be used. Set the same device address as used with the 20-mA unit. The device address is important for distinguishing several 20-mA units that are connected to a serial bus. Set an unambiguous device address on every 20-mA unit, for example, 1, 2 and 3 when connecting 3 of the 20-mA units. On every 20-mA unit, set for the Slave address setting in the 3 functions 20-mA Unit Serial the same device address for each.

Parameter: Unit

- Default setting (_:13111:103) Unit = °C

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

Parameter: Conversion factor

- Default setting (_:13111:104) Conversion factor = 100

The Conversion factor setting allows you to set the conversion factor for the measuring transducer.

Parameter: Resolution

- Default setting (_:13111:108) Resolution = 0.1

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

Parameter: Range active

- Default setting (_:13111:107) Range active = false

If you do not activate the Range active setting (no x in the check box), the function operates over the range 0 mA to 20 mA. The setting of the range for the scaled value goes from a usable range of 0 mA to 20 mA.

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

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

- Default setting (_:13111:105) Upper limit = 20 mA
- Default setting (_:13111:109) Upper limit - Sensor = 100
- Default setting (_:13111:106) Lower limit = 4 mA
- Default setting (_:13111:110) Lower limit - Sensor = 100

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

The following settings and information table shows only 1 of the 12 channels, as the setting possibilities of the 12 channels do not differ.

5.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port E • port F • port J • port N • port P	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 247	1
Channel 1				
_:13111:103	Channel 1:Unit		• % • - • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • in • J • J/Wh • K • l/s • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • Ws • Wh	m

Addr.	Parameter	C	Setting Options	Default Setting
_:13111:108	Channel 1:Resolution		• 1 • 0.1 • 0.01 • 0.001	0.1
_:13111:107	Channel 1:Range active		• 0 • 1	false
_:13111:104	Channel 1:Conversion factor		1 to 10000	100
_:13111:105	Channel 1:Upper limit		0.00 mA to 20.00 mA	20.00 mA
_:13111:109	Channel 1:Upper limit - Sensor		-10000 to 10000	100
_:13111:106	Channel 1:Lower limit		0.00 mA to 20.00 mA	4.00 mA
_:13111:110	Channel 1:Lower limit - Sensor		-10000 to 10000	100

5.6.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Channel 1			
_:13111:53	Channel 1:Health	ENS	O
_:13111:71	Channel 1:Failure	SPS	O
_:13111:301	Channel 1:20-mA output scale	MV	O
_:13111:302	Channel 1:20-mA output raw	MV	O

5.6.5 Communication with 20-mA Unit

5.6.5.1 Integration of a Serial 20-mA Unit

Connection of the Communication Lines

Figure 5-40 shows how to connect the 20-mA unit to the SIPROTEC 5 device. Note that Pin 1 of the RJ45 plug is connected to RTD-B and Pin 2 is connected to RTD-A.

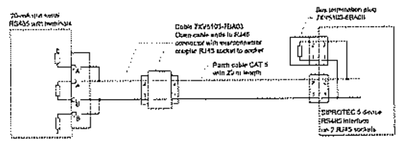

Figure 5-40 Connection of the 20-mA Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART-AB-1EL or a USART-AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

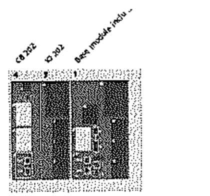

Figure 5-41 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the 20-mA unit.

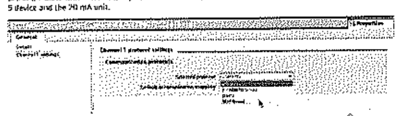

Figure 5-42 Selecting the SUP Protocol

Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the 20-mA unit. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the 20-mA unit. Make sure that the setting values in both devices are the same. The settings of the Non-flickering light (on/off): is not relevant for the RS485 interface.

> **NOTE**
> The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).

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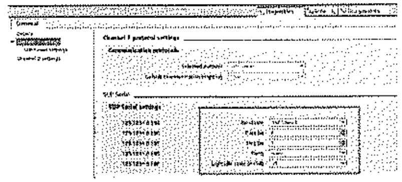

Figure 5-43 Making the Communication Settings

With the selection of the SUP protocol for the 20-mA unit DIGSI automatically adds the function group Analog units to your device configuration. You can now instantiate the function 20-mA unit serial 1 (see following figure).

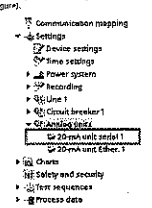

Figure 5-44 Insertion of the Function 20-mA Unit Serial 1

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the 20-mA unit. This address must be set with the same value in the 20-mA unit (refer to the following figure).
For the first use of the 20-mA unit, the following device configuration must be set on the 20-mA unit:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no

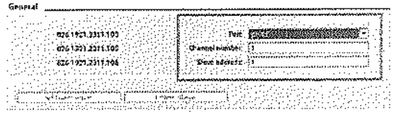

Figure 5-45 Setting the Port, Channel Number, and Device Address

Finally, load the configuration in the device.

5.6.5.2 Integration of a 20-mA Unit Ethernet

Device Configuration

In DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. Figure 5-46 displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

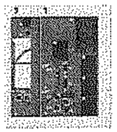

Figure 5-46 Inserting an Ethernet Module

Communication Settings

Activate the SUP Ethernet protocol for the Ethernet module.

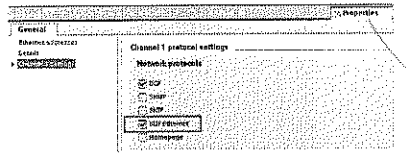

Figure 5-47 Activation of the protocol

This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure)

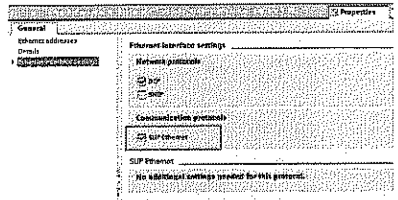

Figure 5-48 Selection of the Protocol

With the selection of the SUP protocol for the 20-mA unit, DIGSI automatically adds the Analog units function group and the 20-mA unit Ether. function to your device configuration (refer to the following figure).

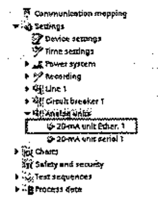

Figure 5-49 Insertion of the Function 20-mA Unit Ether. 1

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the 20-mA unit (refer to the following figure). This address must be set with the same value in the 20-mA unit.

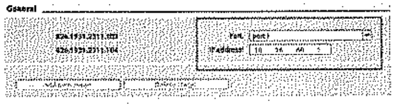

Figure 5-50 Setting the Port and IP Address

Finally, load the configuration in the device.

5.6.6 V/I-Measuring-Transducer Unit with Fast Inputs

5.6.6.1 Overview

The fast analog measuring-transducer inputs process voltage values (DC -10 V to +10 V) as well as current values (DC -20 mA to 20 mA).
The function MT fast input:

- Provides sampled values for recording in the fault record (the maximum sampling frequency is 8 kHz for all other SIPROTEC 5 devices). The recorded sampling frequency results from the setting of the fault recorder function.
- Calculated measured values from the sampled values. These measured values have been deduced from the arithmetic mean values. The measuring range for the mean-value calculation is adjustable in the interval from 10 ms to 100 ms.

- Converts the measured current or voltage values into process values, for example, temperature, gas pressure, etc.
- Provides the recorded process variables for further processing by the fault recorder, the CFC, and in GOOSE-applications for transmission via communication protocols, and for visualization

The fast measuring-transducer inputs are located on the IO212 module with 8 inputs (optionally current or voltage inputs), and the IO210 module with 4 inputs (optionally current or voltage inputs).

5.6.6.2 Structure of the Function

The function **MT fast input** works in the function group **Analog units** and contains the number of available measuring-transducer inputs, depending on the hardware configuration. You can configure these channels independently from one another either as current or voltage inputs.

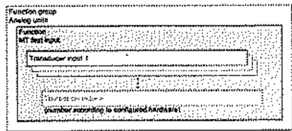

Figure 5-51 Structure/Embedding of the Function

5.6.6.3 Function Description

Once you have instantiated the **MT fast input** function, it will be visible in the project tree in the function group **Analog units**. You can find the function group **Analog units** in DIGSI in the **Settings** folder.
If you open the subdirectory **MT fast input**, you reach the setting sheet for the respective input (for more details, see Application and Setting Notes).
The hardware is designed in such a way that either a current or a voltage can be processed at each input. Use the corresponding terminals (see Hardware manual). Configure the input in accordance with the selected connection (Parameter `TD input-signal type`). With the parameter `Measuring window`, you set the measuring range with which the arithmetic mean value is determined. With the parameter `Measuring window`, you also determine measurement speed for the input. For example, a setting of 100 ms means that the measured value is updated every 100 ms.

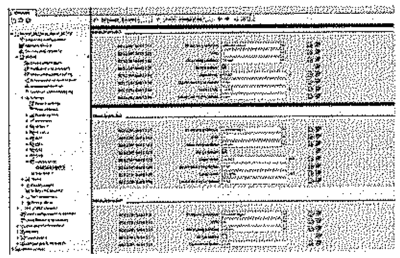

Figure 5-52 Parameters of the Measuring-Transducer Channels

The fast measuring-transducer channels can be configured either as current or as voltage inputs. Apart from this, their function corresponds to the basic function of the 20 mA-channels (see chapter 5.6.5.5 20-mA Channel 1).

5.6.6.4 Application and Setting Notes

Parameter: TD input-signal type

- Default setting (_:101) `TD input-signal type` = `Current input`

With the parameter `TD input-signal type`, you determine whether the measuring-transducer input channel works as a `Current input` or as a `Voltage input`.
Make sure that the selected channel has also been wired correctly (see Hardware manual, Input and Output Module IO212).

Parameter: Unit

- Default setting (_:103) `Unit` = A

With the parameter `Unit`, you set the physical unit of measurement of the measured values. The possible setting values are listed in the settings table.

Parameter: Measuring window

- Default setting (_:142) `Measuring window` = 20 ms

With the parameter `Measuring window`, you set the measuring window that is used to determine the arithmetic mean value from the sampled values. In case of slowly varying signals, Siemens recommends setting the top value to 100 ms. With this value, a new, current measured value is provided every 100 ms for further processing.

Parameter: Range active

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

If you do not activate the Range active parameter, the function assumes a range of -20 mA to +20 mA or -10 V to +10 V. The setting of the range for the scaled value then assumes a usable range of -20 mA to +20 mA or -10 V to +10 V.

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

Note that this setting is activated by either placing, or not placing the relevant check mark in DIGSI (see Figure 5-52).

Parameter: Conversion factor

- Default setting (_:104) Conversion factor = 1.00

With the parameter Conversion factor, you set the conversion factor for the measuring transducer.

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

With the following parameters, you set the scaling of the measuring variables. By that, you can scale in an application-specific way:

- Default setting Upper limit = 20.00 mA
- Default setting Upper limit - Sensor = 1.00
- Default setting Lower limit = -20.00 mA
- Default setting Lower limit - Sensor = 1.00

With these setting parameters, you set the operating range of the measuring transducer as well as the conversion of the values transmitted to the sensor values. Harmonize the operating range of the measuring transducer with the transmitter of the sensor. Using the free scalability of the system, you can meet different requirements. The following figure shows the setting parameters in general terms.

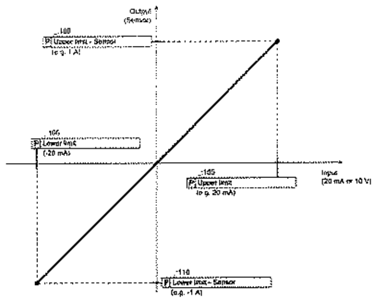

Figure 5-53 Scaling Principle

Setting Example 1:

A measuring transducer transmitting a current signal of 4 mA to 20 mA is used as a transmitter. Currents well below 4 mA indicate a transmitter failure; currents around 0 mA indicate a broken wire. A sensor detecting a temperature is attached to the transmitter. The upper value corresponds to 200 °C and the lower value to -100 °C. This results in the following characteristic. In accordance with the set characteristic curve, the function calculates the sensor value from the measured current. The coefficients of the linear equation (gradient and foot point) are calculated from the set threshold and the sensor values are determined. A supplied current of 9.333 mA corresponds to a temperature of 0 °C.

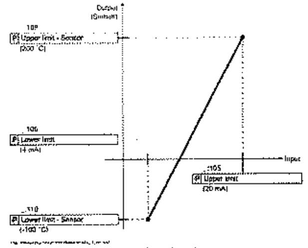

Figure 5-54 Characteristic Curve of Setting Example 1

> **NOTE**
>
> The hardware of the measuring transducer has been designed in such a way that measured values are transmitted and analyzed using the setting range (Upper limit or Lower limit). Therefore, special applications are possible, if necessary. The limits lie at approximately +20 mA and -20 mA or +10 V and -10 V. If the measured values are supplied above or below these limits, the quality invalid is assigned.

Setting Example 2:

For special applications, the transmitter sends a maximum of ±12 V. This voltage shall be issued accordingly as sensor voltage.

Set the parameters as follows:

- Upper limit = 10.00 V
- Upper limit - Sensor = 10.00 V
- Lower limit = -10.00 V
- Lower limit - Sensor = -10.00 V

With this setting, a signal of 12 V is issued as a 12-V measured value (see following figure).

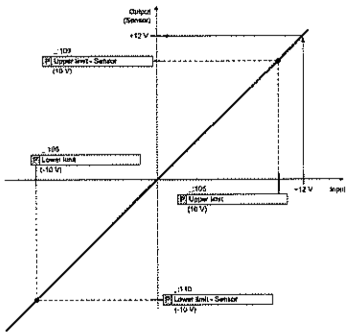

Figure 5-55 Parameter Settings and Representation of an Input Signal Greater than 10 V

5.6.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT fast #				
_:101	MT in #:TD input-signal type		• Voltage input • Current input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• • % • ° • °C • °F • Ω • Ω/km • Ω/mi • 1/s • A • As • cos φ • cycles • dB • F/km • F/mi • h • Hz • Hz/s • In • J • J/Wh • K • l/h • m • mi • min • p.u. • Pa • periods • rad • rad/s • s • V • V/Hz • VA • VAh • var • varh • Vs • W • W/s • Wh	A
_:142	MT in #:Measuring window		• 10 ms • 20 ms • 40 ms • 60 ms • 80 ms • 100 ms	10 ms
_:107	MT in #:Range active		• 0 • 1	false
_:104	MT in #:Conversion factor		-10000.00 to 10000.00	1.00
_:105	MT in #:Upper limit		-20.00 mA to 20.00 mA	5.00 mA
_:109	MT in #:Upper limit - Sensor		-10000.00 to 10000.00	1.00

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T & N Energy

Addr.	Parameter	C	Setting Options	Default Setting
_:106	MT in #:Lower limit		-20.00 mA to 20.00 mA	4.00 mA
_:110	MT in #:Lower limit - Sensor		-10000.00 to 10000.00	1.00

5.6.6.6 Information List

No.	Information	Data Class (Type)	Type
MT in #			
_:302	MT in #:TD scale MV	MV	O
_:306	MT in #:TD scale SAV	SAV	O

5.6.7 RTD Unit Ethernet

5.6.7.1 Overview

The RTD unit Ether. function:

- Communicates with an external RTD unit via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature monitoring function
- Monitors communication with the RTD unit

5.6.7.2 Structure of the Function

The RTD unit Ether. function can only work in the Analog units function group. A maximum of 20 function instances can work simultaneously. Each instance contains 12 preconfigured sensor function blocks.

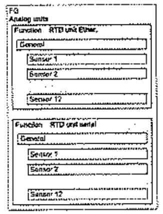

Figure 5-56 Structure/Embedding of the Function

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5.6.7.3 Communication with an RTD Unit

Logic

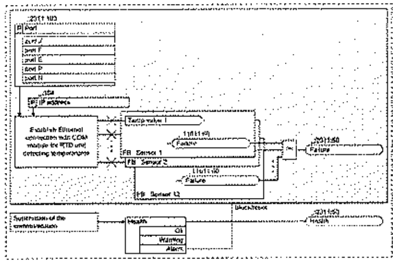

Figure 5-57 Logic of the RTD Unit Ether. Function

Communication with an RTD Unit

The function is used to communicate with an RTD box connected via an Ethernet connection. If the connection of the function is successfully established to the external RTD box via the Ethernet interface, the RTD box transmits the temperatures of all connected sensors to the RTD box Ether. function. For the connection to be established successfully, specific communication settings must be set, see chapter 5.6.7.4 *Application and Setting Notes*.

The RTD box **Ziehl TR1200 IP** supports only an Ethernet connection of 10 Mbit/s. A direct connection to a 100-Mbit communication module is therefore not possible. For this reason, you must connect the RTD box to the communication module via a 10/100 Mbit/s autosensing switch which automatically recognizes the transmission rates and adapts them accordingly. Further information can be found in the Application and setting notes, see chapter *5.6.7.4 Application and Setting Notes*.

Error Responses

The following table lists the conditions under which the *Health* status transitions to the Alarm or Warning state.

Table 5-11 Error Responses

Error Description	Status Health
The RTD unit Ether. function cannot establish a connection with a communication module.	Alarm
The connection between the communication module and the RTD unit causes a time-out.	Warning

Error Description	Status Health
A communication module has not received any more data from the RTD unit for 9 sec.	Warning

The *Failure* signal is set as soon as one of the sensor function blocks reports a failure.

5.6.7.4 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = port J

Use the Port parameter to define over which port the external RTD unit is connected to the SIPROTEC 5 device.

If you want to connect the external RTD unit to the integrated Ethernet interface, set the parameter Port = Port J. If you want to connect the external RTD unit to an Ethernet plug-in module, set the parameter Port = Port F, Port E, Port P, or Port N.

You can connect directly the RTD unit to the device via the internal 10-Mbit Ethernet port J. If you operate the RTD unit on another port via a 100-Mbit communication module, you need an interconnected 10/100-Mbit autosensing switch, which adapts transmission rates accordingly.

Parameter: IP address

- Default setting (_:2311:104) IP address = 10.16.60.1

With the IP address parameter, you set the IP address of the RTD unit connected to the communication module via the SUP protocol. Every RTD unit has to be assigned a unique IP address. The IP address to be set depends on your network configuration. You can set any valid IPv4 address that does not cause conflicts with other IP addresses in the network. Set an appropriate IP address first at the **Ziehl TR1200 IP** RTD unit. Then specify the IP address parameter for the communication module to the same address.

Settings on the RTD Unit

The **Ziehl TR1200 IP** RTD unit is set with the front keys or in a Web browser on a laptop computer via its Ethernet interface. Set the connection type of the sensors (3-wire connection or resistance value for 2-wire connection), the idle state of the fault-indication relay, as well as the IP interface setting.

The code lock has to be switched off for parameterization. This is only possible using the front keys of the RTD unit. The code lock is off (switched off) in as-delivered condition and has pin **504**.

For detailed information on the settings, refer to the TR1200 IP manual that comes with the RTD unit. The documents are also available in the SIPROTEC download area (http://www.siprotec.de) under **Accessories -> 7XV5662-xAD**.

For an Ethernet connection to a SIPROTEC 5 device communicating with the RTD unit TR1200 IP via the SUP protocol (Slave Unit Protocol), the **Modbus TCP** setting must be activated in the RTD unit. You can activate the Modbus TCP protocol using the function keys under the TCP - mod menu item or with the Web browser in the **TCP/UDP Config** tab. The **ETD** (RTD protocol) and **UDP Port** settings have no effect here. The Modbus TCP port is permanently set to 502 and cannot be changed.

5.6.7.5 Temperature Sensor

Logic

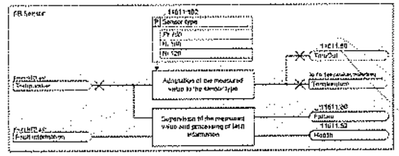

Figure 5-58 Logic Diagram of the Temperature Sensor Function Block

Measured Temperature Value

The Temperature sensor function block processes one single measured temperature value delivered from the RTD box for the assigned sensor. 12 temperature sensor function blocks are always available in each RTD box function (both via Ethernet and serial), even if fewer sensors are connected to the RTD box.

Various temperature sensor types are supported: Pt100, Ni100, and Ni120 sensors. The function block is notified regarding the selection of connected type via the Sensor type parameter.

The function block delivers a measured temperature value in °C or °F as an output variable. The measured temperature value is available as an operational measured value and can be monitored by the Temperature supervision function.

Error Responses

If the measured input value is determined to be incorrect, the quality attribute of the output measured temperature value is set to *invalid*. The statuses for Health and Error take the statuses in accordance with the following table:

Table 5-12 Error response

Error Description	Health Status	Error Status
Sensor or line short circuited	Alarm	Yes
Sensor or line interrupted	Alarm	Yes
Measured temperature value outside the valid measuring range specified in the technical data. The valid measuring range depends on the sensor type.	Alarm	Yes
Sensor not connected	OK	No

5.6.7.6 Application and Setting Notes

Parameter: Sensor type

- Default setting (_:11611:102) Sensor type = Pt 100

The Sensor type parameter is used to set the sensor element used. You can select between Pt 100, Ni 100 and Ni 120.

Parameter: Temperature unit

To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly.

Proceed as follows:

- In DIGSI select the menu item **Extras --> Settings**.
- In the **Settings** view select the menu item **DIGSI 5 User preferences**.
- Under **Standard unit system** change the setting value of the unit system used from *SI units* to *US units*.

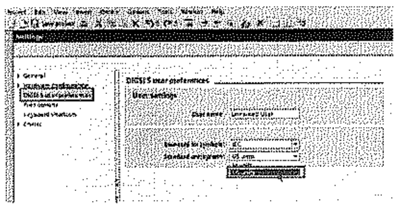

Figure 5-59 Change of the Display Between °C and °F

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.6.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port F • port E • port J • port N • port P	port J
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.6.7.8 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O

No.	Information	Data Class (Type)	Type
Sensor 1			
_:11611:52	Sensor 1:Health	ENS	O
_:11611:50	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O

5.6.8 RTD Unit, Serial

5.6.8.1 Overview

The RTD unit serial function:

- Communicates with an external RTD unit serial via the Slave Unit Protocol (SUP) and records the measured temperatures from the RTD unit
- Provides the captured temperatures to the temperature supervision function
- Monitors communication with the RTD unit

The RTD unit Serial function is set up structurally in the same manner as the RTD unit Ether. function. The mode of operation is also identical (see 5.6.7.3 *Communication with an RTD Unit*).

5.6.8.2 Application and Setting Notes

Parameter: Port

- Default setting (_:2311:103) Port = F

With the Port parameter, you set the slot for the communication module that will be used for the connection with an external RTD unit.

If you want to connect the external RTD box to an Ethernet plug-in module, set the parameter Port = Port F, Port E, Port P, or plug-in module position.

Parameter: Channel number

- Default setting (_:2311:105) Channel number = 1

A serial communication module optionally uses 2 channels. With the Channel number settings, you set the channel number (1 or 2) through which the RTD unit is connected to the device. The communication module inputs are labeled with the channel numbers.

Parameter: Slave address

- Default setting (_:2311:106) Slave address = 1

Use the Slave address parameter to define the device address of the RTD unit. If only one RTD unit is connected to the serial bus, the default value 1 can be used. The same device address has to be set on the RTD unit. The device address is important for distinguishing among several RTD units connected to a serial bus. Set a unique device address (for example 1, 2 and 3 when connecting 3 RTD units) for each RTD unit and the same device address for the parameter Slave address in the 3 RTD unit serial functions.

The following settings and information table shows only 1 of the 12 sensors, as the setting possibilities of the 12 sensors do not differ.

5.6.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:103	General:Port		• port F • port E • port P • port N • port J	port J
_:2311:105	General:Channel number		1 to 2	1
_:2311:106	General:Slave address		1 to 254	1
Sensor 1				
_:11611:102	Sensor 1:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 2				
_:11612:102	Sensor 2:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 3				
_:11613:102	Sensor 3:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 4				
_:11614:102	Sensor 4:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 5				
_:11615:102	Sensor 5:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 6				
_:11616:102	Sensor 6:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 7				
_:11617:102	Sensor 7:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 8				
_:11618:102	Sensor 8:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 9				
_:11619:102	Sensor 9:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 10				
_:11617:102	Sensor 10:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

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Addr.	Parameter	C	Setting Options	Default Setting
Sensor 11				
_:11611:102	Sensor 11:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100
Sensor 12				
_:11611:102	Sensor 12:Sensor type		• Pt 100 • Ni 100 • Ni 120	Pt 100

5.6.8.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
_:2311:56	General:Failure	SPS	O
Sensor 1			
_:11611:52	Sensor 1:Health	ENS	O
_:11611:60	Sensor 1:Failure	SPS	O
_:11611:80	Sensor 1:TmpOut	MV	O
Sensor 2			
_:11612:52	Sensor 2:Health	ENS	O
_:11612:60	Sensor 2:Failure	SPS	O
_:11612:80	Sensor 2:TmpOut	MV	O
Sensor 3			
_:11613:52	Sensor 3:Health	ENS	O
_:11613:60	Sensor 3:Failure	SPS	O
_:11613:80	Sensor 3:TmpOut	MV	O
Sensor 4			
_:11614:52	Sensor 4:Health	ENS	O
_:11614:60	Sensor 4:Failure	SPS	O
_:11614:80	Sensor 4:TmpOut	MV	O
Sensor 5			
_:11615:52	Sensor 5:Health	ENS	O
_:11615:60	Sensor 5:Failure	SPS	O
_:11615:80	Sensor 5:TmpOut	MV	O
Sensor 6			
_:11616:52	Sensor 6:Health	ENS	O
_:11616:60	Sensor 6:Failure	SPS	O
_:11616:80	Sensor 6:TmpOut	MV	O
Sensor 7			
_:11617:52	Sensor 7:Health	ENS	O
_:11617:60	Sensor 7:Failure	SPS	O
_:11617:80	Sensor 7:TmpOut	MV	O
Sensor 8			
_:11618:52	Sensor 8:Health	ENS	O
_:11618:60	Sensor 8:Failure	SPS	O
_:11618:80	Sensor 8:TmpOut	MV	O

No.	Information	Data Class (Type)	Type
Sensor 9			
_:11619:52	Sensor 9:Health	ENS	O
_:11619:60	Sensor 9:Failure	SPS	O
_:11619:80	Sensor 9:TmpOut	MV	O
Sensor 10			
_:11611:52	Sensor 10:Health	ENS	O
_:11611:60	Sensor 10:Failure	SPS	O
_:11611:80	Sensor 10:TmpOut	MV	O
Sensor 11			
_:11611:52	Sensor 11:Health	ENS	O
_:11611:60	Sensor 11:Failure	SPS	O
_:11611:80	Sensor 11:TmpOut	MV	O
Sensor 12			
_:11611:52	Sensor 12:Health	ENS	O
_:11611:60	Sensor 12:Failure	SPS	O
_:11611:80	Sensor 12:TmpOut	MV	O

5.6.9 Communication with RTD Unit

5.6.9.1 Integration of a Serial RTD Unit (Ziehl TR1200)

Connection of the Communication Lines

Figure 5-60 shows how you connect the RTD box to the SIPROTEC 5 device. Note that Pin 1 of the RS45 plug is connected to RTD B and Pin 2 is connected to RTD A.

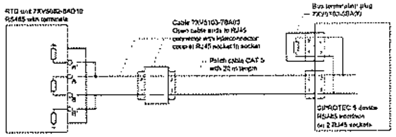

Figure 5-60 Connection of the RTD Unit to the SIPROTEC 5 Device

Adding a USART Module

Add a USART AB-1EL or a USART AC-2EL USART module in DIGSI to the device. The USART module must be inserted at one of the plug-in positions for communication modules in the base module or in the CB202 expansion module (refer to the following figure).

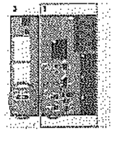

Figure 5-61 Insertion Position for a USART Module

Selecting the SUP Protocol

Select the Slave Unit Protocol (SUP). This protocol is responsible for the communication between the SIPROTEC 5 device and the RTD Unit.

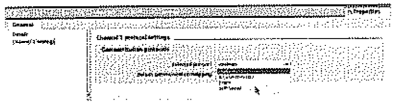

Figure 5-62 Selecting the SUP Protocol

Communication Settings

Make the communications settings for the relevant serial channels. For this, use the default settings specified by the RTD box. Normally, you must adapt only the parameterization of the SIPROTEC 5 device to the settings of the RTD box. Make sure that the setting values in both devices are the same. The settings of the Non-Flickering light (on/off) is not relevant for the RS485 interface.

> **NOTE**
>
> The driver for the USART module for the SUP protocol is not preinstalled as standard for the initial use of this interface (following the firmware update).

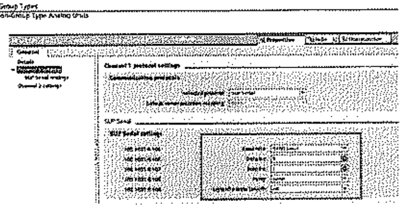

Figure 5-63 Making the Communication Settings

With the selection of the SUP protocol for the RTD box DIGSI automatically adds the function group Analog units to your device configuration. You can now instantiate the function RTD box serial 1 (refer to the following figure).

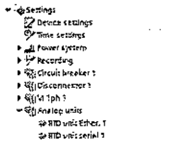

Figure 5-64 Analog-Unit Instance

Now, set the channel number over which the SUP protocol runs. In addition, set the slave address of the RTD box. This address must be set with the same value in the RTD box (refer to the following figure).

The following device configuration must be set on the TR1200 RTD unit when the RTD unit is used for the first time:

- Bus protocol: mod
- Device address: 1
- Baud rate: 9600
- Parity: no

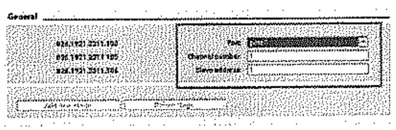

Figure 5-65 Setting the Port, Channel Number, and Slave Address

Finally, load the configuration in the device.

5.6.9.2 Integration of an RTD-Unit Ethernet (TR1200 IP)

Device Configuration

In the DIGSI, insert an Ethernet module into the provided slot, thus, adding the module to the device configuration. Figure 5-66 displays the available slots in the base module or on the expansion module CB 202. Alternatively, you can also use the integrated Ethernet interface Port J.

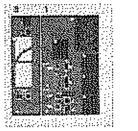

Figure 5-66 Inserting an Ethernet Module

Communication Settings

Activate the SUP Ethernet protocol for the Ethernet module.

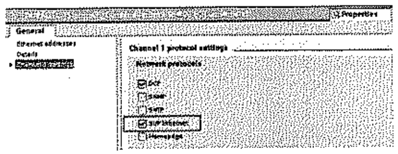

Figure 5-67 SUP Ethernet Protocol Activation

This protocol is also available for Port J of the integrated Ethernet interface of the base module (refer to following figure).

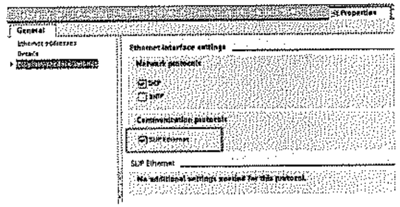

Figure 5-68 SUP Ethernet Protocol Activation (base module)

With the selection of the SUP protocol for the RTD unit, DIGSI automatically adds the Analog units function group and the RTD unit Ether. function to your device configuration (refer to the following figure).

ВЯРНО С ОРИГИНАЛА

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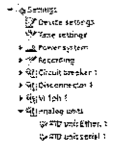

Figure 5-69 Analog Unit Instance

Now, set the port over which the SUP protocol runs. In addition, set the IP address of the RTD box (refer to the following Figure). This address must be set with the same value in the RTD box.

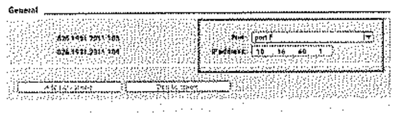

Figure 5-70 Setting the Port and IP Address

Finally, load the configuration in the device.

5.6.9.3 Temperature Simulation without Sensors

Connect a resistor on the sensor terminals of the RTD unit. Using this resistor, simulate a constant temperature. The resistance value should be around 50 Ω to 200 Ω.

If you want to simulate a changeable temperature, connect an adjustable resistor of maximum 470 Ω instead of a fixed resistor.

5.7 Function-Group Type Circuit Breaker

5.7.1 Overview

The Circuit-breaker function group combines all the user functions that relate to a circuit breaker.

You will find the Circuit-breaker function group under each device type in the function library in DIGSI 5. The Circuit-breaker function group contains all of the protection, control, and supervision functions that you can use for this device type. The following figure shows, for example, the functional scope of the Circuit-breaker function group.

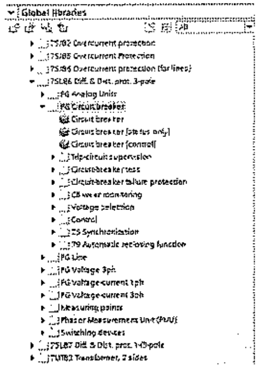

Figure 5-71 Circuit-Breaker Function Group - Example of the Functional Scope

The Circuit-breaker function group includes 3 different types of circuit breakers:

- Circuit breaker
- Circuit-breaker control
- Circuit breaker [status only]

The circuit-breaker type can accept additional basic function blocks for protection functions along with the actual circuit-breaker control.

The circuit breaker [status only] is used only for acquiring the circuit-breaker switch position. This type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

The available functions are described in the chapters 6 Protection and Automation Functions and 8 Control Functions.

5.7.2 Structure of the Function Group

Besides the user functions, the Circuit-breaker function group contains certain functionalities that are essential for general purposes and therefore cannot be loaded or deleted:

- Trip logic
- Mapping the physical circuit breaker
- Circuit-breaker position recognition for protection functions
- Detection of manual closure
- General settings

The following figure shows the structure of the Circuit-breaker function group. The individual function blocks in the image are described in the following chapters.

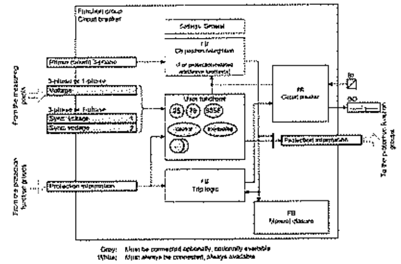

Figure 5-77 Structure of the Circuit-Breaker Function Group

The Circuit-breaker function group has interfaces with:

- Measuring points
- Protection function groups

Interfaces with Measuring Points

The function group contains the measured values needed from the measuring points associated with this function group.

If an application template is used, the function group is connected to the measuring point of the 3-phase current because this connection is essential. It can be necessary to connect additional measuring points to the function group, depending on the nature of the user functions used. Configuration is carried out using the **Function-group connections** editor in DIGSI 5. You can find more detailed information on this in chapter *2.1 Function Embedding in the Device*.

If a user function, for example, synchronization, is used in the function group but the required measuring point has not linked to it, DIGSI 5 reports an inconsistency. This inconsistency provides an indication of the missing measuring-point connection.

The **Circuit-breaker** function group has interfaces with the following measuring points:

- `3-phase line current`
  The measurands from the 3-phase power system are supplied via this interface. The function group must always be connected to this measuring point.
- `Voltage`
  The measurands of the 3-phase voltage system or 1-phase voltage are supplied via this interface. Depending on the connection type of the transformers, in the 3-phase voltage system these are, for example, V_A, V_B, V_C of the line or feeder.
  The connection to the corresponding measuring point is necessary *only* if a user function that needs the measurand of the 3-phase voltage system is used, for example, to make use of the **Synchronization** or **Automatic reclosing** function.
- `Sync. Voltage1, Sync. Voltage2`
  A 1-phase synchronization voltage (for example, voltage of the busbar with a 1-phase connection) or a 3-phase synchronization voltage (for example, voltage of the busbar with a 3-phase connection) is supplied via this interface.
  The connection to the corresponding measuring point is necessary only if synchronization is used.

Interface with Protection-Function Groups

All required data is exchanged between the Protection and Circuit-breaker function groups via the interface with the Protection function group. This data includes, for example, the pickup and operate indications of the protection functions sent in the direction of the Circuit-breaker function group and, for example, the circuit-breaker condition information in the direction of the protection function groups.

If an application template is used, the function groups are connected to each other because this connection is essential to ensure proper operation. You can modify the connection using the **Function-group connections** editor in DIGSI 5.

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

If the connection is missing, DIGSI 5 reports an inconsistency.

Besides the general assignments of the Protection function group or groups to the Circuit-breaker function groups, you can also configure the interface for certain functionalities in detail:

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

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

5.7.3 Application and Setting Notes

Interface with Measuring Points

The interface with the 3-phase power system must have been configured. Otherwise, DIGSI 5 supplies an inconsistency message.

If the Synchronization function is used, the measuring points that represent voltages V1 and V2 of the parts of the electrical power system to be synchronized must be connected.

You can find more detailed information in the chapter *6.x Synchronization Function*.

The **Automatic reclosing** function provides the auxiliary functions **Dead-line check** and **Reduced dead time**. For these auxiliary functions, the 3-phase voltage system has to be measured. If you want to use these auxiliary functions, the measuring point of the 3-phase voltage system must be connected to the **Voltage** function group interface. This connection is also necessary if the **Automatic reclosing function with adaptive dead time** function type is used.

Interface with Protection-Function Groups

The protection-function group is connected to 2 circuit breakers (2 Circuit-breaker function groups) for 1 1/2 circuit-breaker layouts.

Parameter: Rated Normal Current for % Values

- Default setting (`_:2311:101`) `Rated normal current` = `1000 A`

With the `Rated normal current` parameter, you set the primary current which serves as a reference for all current-related % values within the Circuit breaker function group. This applies both for operational measured values and for setting values in %.

Enter the primary rated current of the protected object here.

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

Parameter: Rated Voltage for % Values

- Default setting (`_:2311:102`) `Rated voltage` = `400 kV`

With the `Rated voltage` parameter, you set the primary voltage, which serves as a reference for all voltage-related % values within the Circuit-breaker function group. This applies both for operational measured values and for setting values in %.

Enter the primary rated voltage of the protected object (for example, the line) here.

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

Parameter: Current Threshold Circuit Breaker Open

- Default setting (`_:2311:112`) `Current thresh. CB open` = `0.10 A`

With the `Current thresh. CB open` parameter, you specify the threshold value below which the circuit-breaker pole or the circuit breaker is recognized as open.

Set the `Current thresh. CB open` parameter so that the current measured when the circuit-breaker pole is open will certainly fall below the parameterized value. If parasitic currents (for example, due to induction) are excluded with the line deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to `0.05 A` for example.

If no special requirements exist, Siemens recommends retaining the setting value at `0.10 A` for secondary purposes.

5.7.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV

Addr.	Parameter	C	Setting Options	Default Setting
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing
Trip logic				
_:5341:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<
Circuit break.				
_:4261:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
Control				
_:4201:101	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
_:4201:102	Control:SBO time out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:4201:104	Control:Check switching authority		• no • yes • advanced	yes
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
_:4201:107	Control:Check blk. by protection		• no • yes	yes
Switching authority				
_:4201:151	Control:Swi.dev. related sw.auth.		• 0 • 1	false
_:4201:152	Control:Specific sw. authorities		• 0 • 1	true
_:4201:115	Control:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:4201:153	Control:Num. of specific sw.auth.		2 to 5	2
_:4201:155	Control:Ident. sw.auth. 1		Freely editable text	
_:4201:156	Control:Ident. sw.auth. 2		Freely editable text	
_:4201:157	Control:Ident. sw.auth. 3		Freely editable text	

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Addr.	Parameter	C	Setting Options	Default Setting
_:4201:158	Control:Ident. sw.auth. 4		Freely editable text	
_:4201:159	Control:Ident. sw.auth. 5		Freely editable text	
_:4201:151	Control:Multiple specific sw.auth.		• 0 • 1	false
CB test				
_:6151:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s

5.7.5 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:5341:300	Trip logic:Trip indication	ACT	O
Circuit break.			
_:4261:500	Circuit break.:>Ready	SPS	I
_:4261:501	Circuit break.:>Acquisition blocking	SPS	I
_:4261:502	Circuit break.:>Reset switch statist.	SPS	I
_:4261:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:4261:503	Circuit break.:External health	ENS	I
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position	DPC	C
_:4261:300	Circuit break.:Trip/open cmd.	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O
_:4261:304	Circuit break.:Alarm suppression	SPS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:307	Circuit break.:ΣI Brk.	BCR	O
_:4261:308	Circuit break.:ΣIA Brk.	BCR	O
_:4261:309	Circuit break.:ΣIB Brk.	BCR	O
_:4261:310	Circuit break.:ΣIC Brk.	BCR	O
_:4261:311	Circuit break.:Break.-current phs A	MV	O
_:4261:312	Circuit break.:Break. current phs B	MV	O
_:4261:313	Circuit break.:Break.-current phs C	MV	O
_:4261:314	Circuit break.:Break. voltage phs A	MV	O
_:4261:315	Circuit break.:Break. voltage phs B	MV	O
_:4261:316	Circuit break.:Break. voltage phs C	MV	O
_:4261:322	Circuit break.:CB open hours	INS	O
_:4261:323	Circuit break.:Operating hours	INS	O
Manual close			
_:6541:501	Manual close:>Block manual close	SPS	I
_:6541:500	Manual close:>Input	SPS	I
_:6541:300	Manual close:Detected	SPS	O
Reset LED Group			
_:13381:500	Reset LED Group:>LED reset	SPS	I
_:13381:320	Reset LED Group:LED have been reset	SPS	O

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
CB test			
_:6151:53	CB test:Health	ENS	O
_:6151:301	CB test:Test execution	ENS	O
_:6151:302	CB test:Trip command issued	ENS	O
_:6151:303	CB test:Close command issued	ENS	O
_:6151:304	CB test:Test canceled	ENS	O
_:6151:311	CB test:3-pole open-close	SPC	C

5.7.6 Trip Logic

5.7.6.1 Function Description

The **Trip logic** function block receives the group operate indication from the Protection function group or Protection function groups and forms the protection trip command that is transmitted to the **Circuit-breaker** function block.

The **Circuit-breaker** function block activates the device contact and thus causes the circuit breaker to open (see *5.7.7 Circuit Breaker*). The command output time is also effective here.

The trip logic also decides when the protection trip command is reset (see *Figure 5-74*).

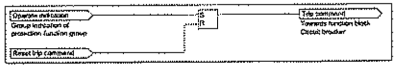

Figure 5-73 Trip Command

Trip-Command Reset

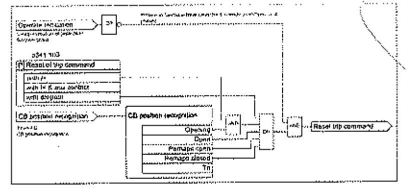

Figure 5-74 Trip-Command Reset

Once a trip command is issued, it is stored (see Figure 5-73).

You determine the criteria for resetting a trip command that has been issued with the parameter `Reset of trip command`.

- `with dropout`

  The trip command is reset if the function that initiated tripping resets its operate indication. This occurs typically with dropout. Command reset of the trip command takes place regardless of verification of the circuit-breaker condition.

- `with I<`

- `with I< & aux.contact`

  For these criteria, the state of the circuit breaker is also taken into account as a further criterion in addition to the dropout of the tripping function (operate indication is reset by command). You can select whether the state is determined by means of the current (`with I<`) or by means of the current in conjunction with the circuit breaker auxiliary contacts (`with I< & aux.contact`). The behavior of these setting options only differs in one situation of the circuit-breaker state. If the circuit breaker is in the opening state, the trip command is reset in the case of the option `with I<`, whereas it is not reset yet in the case of the option with `with I< & aux.contact`. The opening state is detected if the auxiliary contacts still detect the circuit breaker as being closed and opening is detected via the decreasing current flow.

  As long as the circuit breaker is detected unambiguously as closed (fully closed), the trip command will not be reset with those setting options.

  The information about the condition of the circuit breaker is supplied by the **Circuit-breaker position recognition** function block (see *5.7.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions*). The determination of the various conditions is also described in this chapter.

5.7.6.2 Application and Setting Notes

Parameter: Reset of trip command

- Recommended setting value (_:5341:103) `Reset of trip command` = `with I<`

Parameter Value	Description
`with I<`	With this setting, the trip command is reset as soon as the current is removed, provided the tripping function has dropped out. The most important factor for recognition of the open circuit breaker is the current falling short of the value set in the parameter (_:2311:112) `Current thresh. CB open`.
`with I< & aux.contact`	For this setting not only the current has to be removed, but also the circuit-breaker auxiliary contact has to report that the circuit breaker is open. This setting assumes that the setting of the auxiliary contact has been routed via a binary input (for more information, see *5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).
`with dropout`	The setting can be selected for special applications in which the trip command does not result in complete interruption of the current in every case. In this case, the trip command is reset if the pickup of the tripping protection function drops out. The setting is useful if the load current in the system cannot be interrupted during the protection device test and the test current is fed in parallel with the load current.

5.7.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<

5.7.6.4 Information List

No.	Information	Data Class (Type)	Type
Trip logic			
_:300	Trip logic:Trip indication	ACT	O

5.7.7 Circuit Breaker

5.7.7.1 Overview

The **Circuit-breaker** function block represents the physical switch in the SIPROTEC 5 device.

The basic tasks of this function block are the operation of the circuit breaker and the acquisition of the circuit-breaker auxiliary contacts and other circuit-breaker information.

The **Circuit-breaker** function block provides information about:

- Number of switching cycles
- Breaking current, breaking voltage, and breaking frequency
- Summation breaking current

5.7.7.2 Tripping, Opening, and Closing the Circuit Breaker

The circuit breaker is operated in the following situations:

- Tripping of the circuit breaker as a result of a protection trip command
- Opening of the circuit breaker as a result of control operations
- Closing of the circuit breaker as a result of automatic reclosing or control operations

Tripping is always the result of a protection function. The operate indications of the individual protection functions are summarized in the **Trip logic** function block. The trip command that causes the tripping in the **Circuit breaker** function block is generated there.

To operate the circuit breaker, the **Circuit-breaker** function block provides the output signals that must be routed to the corresponding binary outputs of the device (see *Table 5-13*).

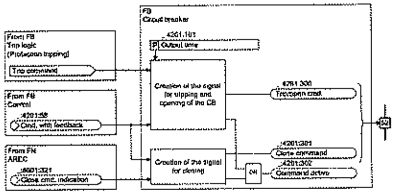

Figure 5-75 Tripping, Opening, and Closing the Circuit Breaker

Table 5-13 Description of the Output Signals

Signal	Description	Routing Options
`Trip/open cmd.`	This signal executes all tripping and opening operations. The `Output time` parameter affects the signal. The signal is pending for the duration of this period, with the following exceptions: • Only when switched off by the control: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is open before expiration of the period. • Only in the event of protection tripping: The signal remains active as long as the trip command is still active after expiration of the period (see also 5.7.6.1 Function Description). • Only in the event of protection tripping: With the routing option **Only saved in the event of tripping**, the signal remains pending until it is acknowledged manually. This only applies for protection tripping.	• Unlatched • Only saved in the event of protection tripping (not when opened)
`Close command`	This signal executes all closing operations. The `Output time` parameter affects the signal. The signal is pending for the duration of this period, with the following exception: The signal is canceled before expiration of the period if the auxiliary contacts report that the circuit breaker is closed before expiration of the period	Normal routing
`Command active`	This signal is active as long as one of the binary outputs assigned to the signals `Trip/open cmd.` and `Close command` is active because a switching command is being executed by the control.	Normal routing

5.7.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information

To determine the circuit breaker position, the **Circuit-breaker** function block provides position signals (see next figure).

These signals are of the **Double-point indication** (DPC) type. A double-point indication can be routed to 2 binary inputs so that the open and closed circuit-breaker positions can be reliably acquired.

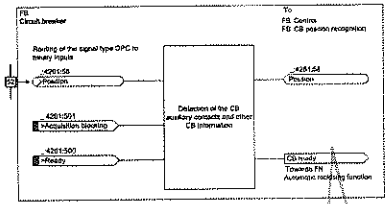

Figure 5-76 Acquisition of the Circuit-Breaker Information

Signal	Type	Description
`Position`	DPC	Acquisition of the circuit-breaker position The position **3-pole circuit breaker open** and/or the position **3-pole circuit breaker closed** can be acquired by routing to 1 or 2 binary inputs.

The signals must be routed to the binary input that is connected with the CB auxiliary contacts. The open and closed signals do not necessarily have to be routed in parallel. The advantage of parallel routing is that it can be used to determine an intermediate or disturbed position. On the other hand, this is not possible if only one signal is routed.

In the monitoring direction, the position signals generate the following information when the open and closed positions are acquired (see following table). This information is further processed by the **Circuit-breaker position recognition** and **Control** function blocks.

Information	Type	Description
Off	SPS	Circuit-breaker position is opened.
On	SPS	Circuit-breaker position is closed.
Intermediate position	SPS	Circuit breaker position is in intermediate position.
Disturbed position	SPS	Circuit-breaker position is in disturbed position.
Not selected	SPS	The circuit breaker is not selected for a control operation.

Other input signals are:

Signal	Type	Description
`>Acquisition blocking`	SPS	This is used to activate acquisition blocking of the circuit-breaker auxiliary contacts (see Other Functions 3.8.7 Persistent Commands for a description of acquisition blocking).

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Signal	Type	Description
>Reset AcqBlk&Subst	SPS	This is used to reset Acquisition blocking and manual update of the circuit breaker. Setting acquisition blocking and tracking is blocked with the input activated.
>Ready	SPS	The active signal indicates that the circuit breaker is ready for an OFF-ON-OFF cycle. The signal remains active as long as the circuit breaker is unable to trip. The signal is used in the Automatic reclosing and Circuit-breaker test functions.

Another output signal is:

External health	SPS	This can be used to indicate the health of the physical circuit breaker. For this, you must acquire any failure information for the circuit breaker via a binary input. This failure information can set the appropriate state of the External health signal with a CFC chart (using the BUILD_ENS block). The signal has no effect on the health of the function block.

5.7.7.4 Definitive Tripping, Circuit-Breaker Tripping Alarm Suppression

Definitive Tripping

Definitive tripping is always pending whenever the Automatic reclosing (AREC) function does not carry out any reclosing after tripping. It follows that this is the case whenever an automatic reclosing is not present or the AREC has been switched off.

Circuit-Breaker Tripping Alarm Suppression

In certain systems, the user may wish to activate an alarm (for example, a horn) when tripping (circuit-breaker tripping) occurs. This alarm should not to be issued if the circuit breaker is to be reclosed automatically after tripping or if it is to be closed or opened via the control. The alarm is only to be issued in the event of final tripping.

Depending on how the alarm is generated (for example, triggered by a fleeting contact of the circuit breaker), the Alarm suppression signal can be used to suppress the alarm.

The signal is generated if:

- A definitive protection tripping is not present
- The automatic reclosing function executes a closure
- The integrated control executes a closure or opening action
- External closing is detected via the Manual close function

For further information about its use, please refer to 5.7.9.2 *Application and Setting Notes*.

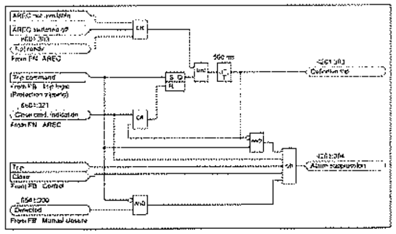

Figure 5-77 Definitive Tripping, Circuit-Breaker Tripping Alarm Suppression

5.7.7.5 Tripping and Opening Information

When a trip command is issued, the tripping information shown in the next figure is saved in the fault log.

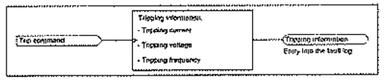

Figure 5-78 Tripping Information

The following statistics information is saved for the circuit breaker:

- Number of switching cycles:
  All tripping, opening, and closing operations are counted.
- Number of closing operations by the automatic reclosing function
- Total of tripping and breaking currents

The statistics information can be individually set and reset via the device control. It is also possible to reset all values via the binary input signal >Reset switch statist..

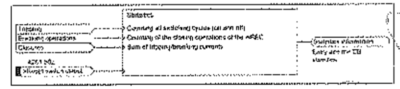

Figure 5-79 Statistics Information About the Circuit Breaker

5.7.7.6 Application and Setting Notes

Routings for Activation of the Circuit Breaker

Figure 5-80 shows the necessary routings:

- The device can execute 3-pole tripping (via the protection device).
- The device can execute 3-pole opening (via the control).
- The device can execute 3-pole closing (via AREC or via the control).

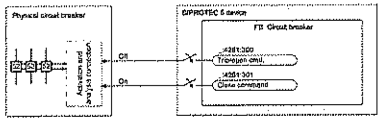

Figure 5-80 Activation of the Circuit Breaker

By routing the Trip/open cmd. signals to 1 or 2 binary outputs, you can carry out 1, 1.5, and 2-pole activations of the circuit breaker. You will find a detailed description of this in 2.2.3 *Connection Variants of the Circuit Breaker*.

> **NOTE**
>
> Do not confuse these 1-pole, 1.5-pole, and 2-pole activations of the circuit breaker with 1-pole or 3-pole tripping of the circuit breaker.

Routing for Analysis of the Circuit-Breaker Switch Position

For certain functions of the device, it is useful to detect the circuit-breaker switch position via its auxiliary contacts. These are for example:

- **Circuit-breaker position recognition** function block
- **Circuit-breaker failure protection** function
- **Control** function block

The operating principle of the auxiliary contacts is described in the individual functions.

Siemens recommends capturing the *Circuit breaker is open in 3 poles* and *Circuit breaker is closed in 3 poles* information via auxiliary contacts. This is the optimal configuration for the control functionality. For purely protection applications, it is also enough to capture just one of the 2 circuit-breaker positions.

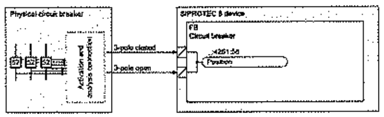

Figure 5-81 Recommended Analysis of the Circuit-Breaker Switch Position when Used as a Protection and Control Device

The following diagram shows the recommended routing, in which H stands for **active with voltage**.

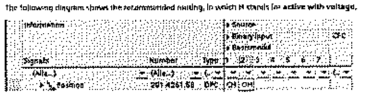

Figure 5-82 Routing for Acquisition of the Circuit-Breaker Switch Position via 2 Auxiliary Contacts

The device can also function without the analysis from the circuit-breaker auxiliary contacts, that is, routing of the auxiliary contacts is not absolutely necessary. However, this is a requirement for control functions.

Parameter: Output time

- Default setting (_:101) Output time = 0.10 s

The Output time parameter acts on the signals for tripping, opening, and closing of the circuit breaker.

> **CAUTION**
>
> Do not set a time that is too short.
>
> **If you set a time that is too short, there is a danger that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.**
>
> ◇ Set a time that is long enough to ensure that the circuit breaker reliably reaches its final position (open or closed) after a control operation.

Output Signal: Indication Suppression

Whereas in the case of feeders without an automatic reclosing function every trip command is final due to a protection function, the use of an automatic reclosing function should only cause the motion detector of the circuit breaker (fleeting contact on the circuit breaker) to trigger an alarm if tripping of the circuit breaker is definitive (see next figure for more details). Likewise, a tripping alarm should not be triggered for switching operations by the control.

For this, the alarm activation circuit should be looped via a suitably routed output contact of the device (output signal Alarm suppression). In the idle state and when the device is switched off, this contact is permanently closed. For this, an output contact with a break contact must be routed. The contact opens whenever the output signal Alarm suppression becomes active, so that tripping or a switching operation

does not cause an alarm (see the logic in 5.7.7.3 *Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information* for more details).

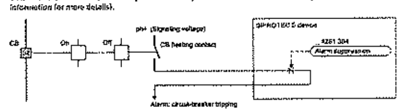

Figure 5-83 Circuit-Breaker Tripping Alarm Suppression

5.7.7.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Circuit break.				
_:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s

5.7.7.8 Information List

No.	Information	Data Class (Type)	Type
Circuit break.			
_:500	Circuit break.:>Ready	SPS	I
_:501	Circuit break.:>Acquisition blocking	SPS	I
_:502	Circuit break.:>Reset switch statist.	SPS	I
_:504	Circuit break.:>Reset AcqBlk&Subst	SPS	I
_:503	Circuit break.:External health	ENS	I
_:53	Circuit break.:Health	ENS	O
_:58	Circuit break.:Position	DPC	C
_:300	Circuit break.:Trip/open cmd.	SPS	O
_:301	Circuit break.:Close command	SPS	O
_:302	Circuit break.:Command active	SPS	O
_:303	Circuit break.:Definitive trip	SPS	O
_:304	Circuit break.:Alarm suppression	SPS	O
_:306	Circuit break.:Op.ct.	INS	O
_:307	Circuit break.:ΣI Brk.	BCR	O
_:308	Circuit break.:ΣIA Brk.	BCR	O
_:309	Circuit break.:ΣIB Brk.	BCR	O
_:310	Circuit break.:ΣIC Brk.	BCR	O
_:311	Circuit break.:Break.-current phs A	MV	O
_:312	Circuit break.:Break.-current phs B	MV	O
_:313	Circuit break.:Break.-current phs C	MV	O
_:314	Circuit break.:Break. voltage phs A	MV	O
_:315	Circuit break.:Break. voltage phs B	MV	O
_:316	Circuit break.:Break. voltage phs C	MV	O
_:322	Circuit break.:CB open hours	INS	O
_:323	Circuit break.:Operating hours	INS	O

5.7.8 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions

5.7.8.1 Overview

This function block calculates the position of the circuit breaker from the evaluation of the auxiliary contacts and the current flow.

This information is needed in the following protection-related additional functions:

- Trip logic (see 5.7.6.1 *Function Description*)
- Detection of manual closing (see 5.7.9.1 *Function Description*)
- Process monitor (Standard VI) 5.8 *Process Monitor*)

Its use is described in the respective chapters.

The control does not use this information. The control evaluates the circuit-breaker auxiliary contacts.

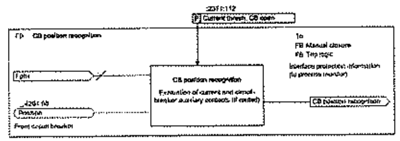

Figure 5-84 Overview of the Circuit-Breaker Condition Position Function

Based on the link between the information from the auxiliary contacts and the current flow, the circuit breaker can assume the following positions:

Circuit-Breaker Condition	Description
Open	The circuit-breaker pole is detected unambiguously as **open** according to both criteria.
Closed	The circuit-breaker pole is detected unambiguously as **closed** according to both criteria.
Possibly open, possibly closed	These conditions can occur if the information is incomplete due to the routing of the auxiliary contacts and the condition can no longer be determined reliably. These uncertain conditions are evaluated differently by certain functions.
Opening	This is a dynamically occurring condition that results when, while a trip command is active and the auxiliary contact is still closed, the current is detected to have fallen below the threshold value because the current-flow criterion takes effect faster than the auxiliary contact can open.

5.7.9 Detection Manual Closure (for AREC and Process Monitor)

5.7.9.1 Function Description

Detection of Manual Closure (for AREC and Process Monitor)

The Manual closure function block detects any closure carried out by hand. This information is used in function, the automatic reclosing (AREC) and Process monitor functions (within protection function groups).

You will find detailed information in the chapters Automatic reclosing function and Process monitor.
The following figure shows the logic for manual closure detection.

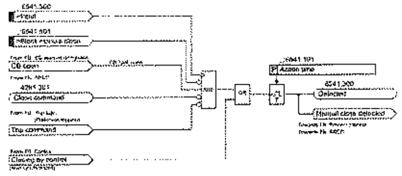

Figure 5-85 Logic for Manual Closure Detection

External Manual Closure

An external manual closure is communicated to the device via the input signal >Input. The input signal can also be connected directly to the control circuit of the circuit-breaker closing coil. For this reason, detection is suppressed in the event of a close command by the AREC function. Detection via the input signal >Input is also blocked if the circuit breaker is closed or if a protection trip is active.

Internal Manual Closure

Manual closure is detected in all cases if a close command is transmitted by the internal control function of the device. This is possible because the control carries out plausibility checks itself and is also subject to interlocking.

5.7.9.2 Application and Setting Notes

Input Signals: >Input, >Blocking of Manual Closure

In practice, the input signal >Input is connected directly to the control circuit of the circuit-breaker closing coil (see following figure).

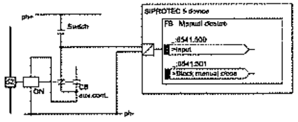

Figure 5-86 Connection of the Input Signal to the Control Circuit of the Circuit-Breaker Closing Coil

Every closure of the circuit breaker is recorded in the process. Therefore, detection is suppressed in the event of a close command by the internal AREC function of the device.

If external close commands are possible (actuation of the circuit breaker by other devices), which are not intended to prompt detection of a manual closure (for example, with an external reclosing device), this can be ensured in 2 ways:

- The input signal is connected in such a way that it is not activated in the event of external close commands.
- The external close command is connected to the blocking input >Block manual close for manual closure detection.

Parameter: Action time

- Recommended setting value (_:101) Action time = 300 ms

In order to ensure independence from manual activation of the input signal, the detection function is extended for a defined length of time using the parameter Action time.
Siemens recommends an action time of 300 ms.

5.7.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Manual close				
_:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s

5.7.9.4 Information List

No.	Information	Data Class (Type)	Type
Manual close			
_:501	Manual close:>Block manual close	SPS	I
_:500	Manual close:>Input	SPS	I
_:300	Manual close:Detected	SPS	O

5.8 Process Monitor

5.8.1 Overview of Functions

All function groups that have functions with dependencies on the state of the protected object contain a process monitor. The process monitor detects the current state of the protected object.

5.8.2 Structure of the Function

The **Process monitor** function is used in the **Standard VI 3-phase** protection function group.
The **Process monitor** function is provided by the manufacturer with the following function blocks:

- Cold-load pickup detection (optional)
- Current-flow criterion
- Circuit-breaker condition
- Closure detection

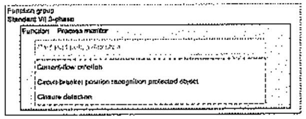

Figure 5-87 Structure/Embedding of the Function

You can activate the cold-load pickup detection as needed. All other stages of the process monitor run permanently in the background and are not displayed in DIGSI.
The following figure shows the relationships of the individual function blocks.

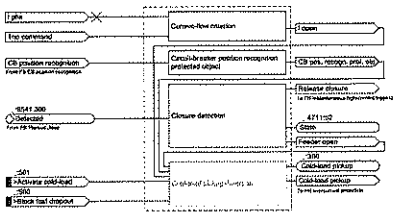

Figure 5-88 Logic Diagram of the Overall Function Process Monitor

5.8.3 Current-Flow Criterion

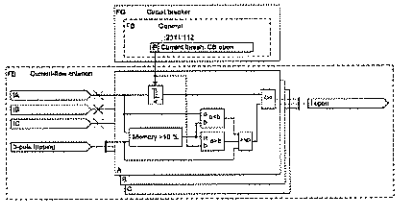

Figure 5-89 Logic Diagram of the Current-Flow Criterion Function Block

The I open signal of one phase is generated if one of the following conditions is met:

- A phase current falls below the set threshold of the Current thresh. CB open parameter. The hysteresis stabilizes the signal.
- The corresponding phase current, for example, I A, falls below 10 % of the phase current when the trip command arrives. If the current does not drop until after a delay due to current transformer influences, an open pole can therefore be detected quickly even after a high-current fault on the line.

With the Current thresh. CB open parameter, you define the minimum current as the criterion for a deactivated line. The parameter lies in the Circuit-breaker function group. It acts both in the Circuit-breaker function group, for example circuit-breaker position recognition, and also for the process monitor in the Protection-function group.

5.8.4 Application and Setting Notes (Current-Flow Criterion)

Parameter: Current thresh. CB open

- Recommended setting value (_:2311:112) Current thresh. CB open = 0.100 A

The Current thresh. CB open parameter is used to define the threshold for the leakage current as the criterion for a deactivated line.
Set the Current thresh. CB open parameter so that the current measured when the feeder is deactivated falls below the value of the Current thresh. CB open parameter with certainty. The hysteresis is additionally active if the threshold is exceeded.
If parasitic currents, for example, due to induction, are ruled out when the feeder is deactivated, set the Current thresh. CB open parameter sensitively.
Siemens recommends a setting value of 0.100 A.

5.8.5 Circuit-Breaker Condition for the Protected Object

Logic

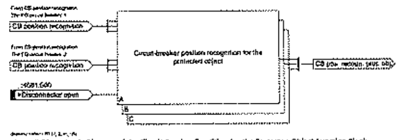

Figure 5-90 Logic Diagram of the Circuit-Breaker Condition for the Protected-Object Function Block

The circuit-breaker position recognition in the Circuit breaker (CB) function group provides the circuit-breaker condition by way of the internal signal CB pos. recogn. prot. obj..
If a protected object is supplied via 2 circuit breakers (CBs), for example with the 1 1/2 circuit-breaker layout, then the circuit-breaker switch positions of the protected object must be determined with the aid of both circuit breakers. In this case, the Circuit-breaker position recognition for the protected object function block connects the individual CB states. The connection provides the internal CB pos. recogn. prot. obj. signal to the other function blocks of the process monitor and to other functions, for example, Trip in the event of weak infeed and Echo function for teleprotection method, within the same function group.
If one of the following 2 conditions is met, the CB pos. recogn. prot. obj. signal is in the Open state.

- All connected circuit breakers signal the Open state internally.
- The >Disconnector open input is active.

If the following 2 conditions are met, the CB pos. recogn. prot. obj. signal is in the Closed state:

- At least one of the connected circuit breakers signals the Closed state internally.
- The >Disconnector open input is not active.

ВЯРНО С ОРИГИНАЛА

5.8.6 Closure Detection

The closure detection enables the immediate tripping of selected protection functions or protection stages when switching to short circuit or the reduction of the responsivity. The closure detection determines whether the protected object is switched on.

Logic

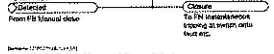

Figure 5-91 Logic Diagram of Closure Detection

For an applied binary input signal Detected (from Manual close function block), the indication Closure is active.

5.8.7 Information List

No.	Information	Data Class (Type)	Type
Closure detec.			
_:4681:500	Closure detec.:>Disconnector open	SPS	I
_:4681:300	Closure detec.:Closure	SPS	O

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5.8.8 Cold-Load Pickup Detection (Optional)

Logic

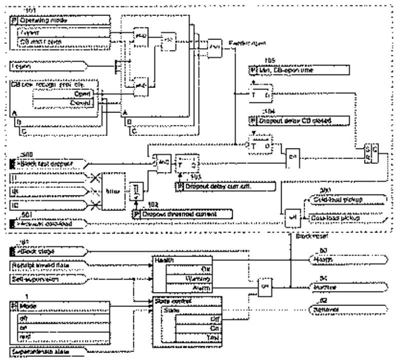

Figure 5-92 Logic Diagram of the Cold-Load Pickup Detection Function Block

The **Cold-load pickup detection** function block detects that a specific time has been exceeded after deactivation of the line or protected object. If you want to connect the protected object again, you must note that an increased load-current requirement exists for a limited time after connection. This results from the nature of the load.

The **Cold-load pickup detection** function block ensures that different parameters are used for an adjustable time after connection. For example, for the time of the Min. CB-open time parameter, you can increase the threshold value of a protection function or you can select a special characteristic curve.

If the **Cold-load pickup detection** function block detects an open feeder and the set time of the Min. CB-open time parameter has expired, the indication >Activate cold-load is generated.

With the >Activate cold-load indication, you can activate a parameter set of the **Cold-load pickup** function. Via the binary input signal >Activate cold-load, you can also activate the >Activate cold-load indication directly.

If the **Cold-load pickup detection** function block detects closure and the corresponding load current, it starts the time set in the Dropout delay CB closed parameter. The >Activate cold-load indication and the activated parameter set are deactivated after this time has elapsed.

If, for the time set in the Dropout delay curr.crit. parameter, the maximum phase current falls below the threshold value Dropout threshold current, the parameter set for the Cold-load pickup detection function block is also deactivated. As a result, if the load current is very low, the dropout time Dropout delay curr crit. of the >Activate cold-load indication can be shortened.

5.8.9 Application and Setting Notes (Cold-Load Pickup Detection)

NOTE

The settings and indications described in this chapter are only available when using the optional Cold-load pickup detection function block.

Parameter: Operating mode

- Default setting (_:101) Operating mode = I open

With the Operating mode parameter, you set the criteria with which the Closure-detection function block operates.

Parameter Value	Description
I open	When the Current-flow criterion function block detects a clearing open condition, the decision is made for pickup. For this setting, make sure that the Current thresh. CB open parameter is set lower than the possible load current. If this is not the case, open is detected continuously and each fault current that exceeds the Current thresh. CB open parameter is interpreted as closure.
CB and I open	Closure is detected if one of the following conditions is met: - Analysis of the circuit-breaker auxiliary contact detects a clearing open condition in at least one phase. - The current-flow criterion detects a clearing open condition.

Parameter: Dropout threshold current

- Default setting (_:102) Dropout threshold current = 1.00 A

With the Dropout threshold current parameter, you set the threshold at which the output signal Cold-load pickup is deactivated when the current in at least one phase falls below this threshold.

Parameter: Dropout delay current criterion

- Default setting (_:103) Dropout delay curr.crit. = 600 s

With the Dropout delay curr.crit. parameter, you set the time for which the actual value must be below the Dropout threshold current threshold so that the output signal Cold-load pickup can be deactivated prematurely.

Parameter: Dropout delay CB closed

- Default setting (_:104) Dropout delay CB closed = 3600 s

With the Dropout delay CB closed parameter, you set the action time for the dynamic parameter set switching in the event of cold load pickup detection.

Parameter: Min. CB open time

- Default setting (_:105) Min. CB-open time = 3600 s

With the Min. CB-open time parameter, you set the time after which the dynamic parameter set is activated in the event of cold-load pickup when the line is opened.

5.8.10 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Cold-load PU				
_:1	Cold-load PU:Mode		• off • on • test	off
_:101	Cold-load PU:Operation mode		• I open • CB and I open	I open
_:102	Cold-load PU:Dropout threshold current	1 A @ 100 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 10.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 50.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:103	Cold-load PU:Dropout delay curr.crit.		1 s to 600 s	600 s
_:104	Cold-load PU:Dropout delay CB closed		1 s to 21600 s	3600 s
_:105	Cold-load PU:Min. CB-open time		0 s to 21600 s	3600 s

5.8.11 Information List

No.	Information	Data Class (Type)	Type
Cold-load PU			
_:81	Cold-load PU:>Block stage	SPS	I
_:500	Cold-load PU:>Block fast dropout	SPS	I
_:501	Cold-load PU:>Activate cold-load	SPS	I
_:54	Cold-load PU:Inactive	SPS	O
_:52	Cold-load PU:Behavior	ENS	O
_:53	Cold-load PU:Health	ENS	O
_:300	Cold-load PU:Cold-load pickup	SPS	O

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6 Protection and Automation Functions

6.1 Power-System Data

6.1.1 Overview

The Power-system data are provided with each SIPROTEC 5 device and cannot be deleted. You will find them in DIGSI under Settings → Power-system data.

6.1.2 Structure of the Power-System Data

The Power-system data contain the block General and the Measuring points of the device. The following figure shows the structure of the Power-system data.

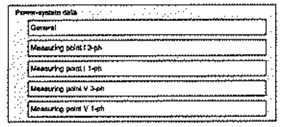

Figure 6-1 Structure of the Power-System Data

In order to adjust its functions to the application, the device requires some data about the power system. The necessary settings can be found in the Power-system data under General as well as in the Measuring points.

> **NOTE**
>
> You can find information on the supervision function parameters in chapter 9.3 *Supervision of the Secondary System*.

Type and scope of the required measuring points depend on the application. Possible measuring points are:

- Voltage 3-phase (measuring point V 3-ph)
- Current 3-phase (measuring point I 3-ph)
- Voltage 1-phase (measuring point V 1-ph)
- Current 1-phase (measuring point I 1-ph)

The measuring points have interfaces to the function groups requiring voltage and/or current measured values of the power system.

6.1.3 Application and Setting Notes – General Settings

Parameter: Phase sequence

- Recommended setting value (_:2311:101) `Phase sequence` = `ABC`

The parameter `Phase sequence` is used to set the phase sequence (ABC) or (ACB). The setting value applies to the entire SIPROTEC 5 device.

Use the General function to set the settings in the power-system data.

6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph)

The following example describes the settings of the voltage measuring point Measuring point V-3ph (voltage 3 phase). Settings for the supervision functions are also located in the voltage measuring point. The description of these settings can be found in chapter Supervision Functions.

Parameter: Rated primary voltage

- Default setting (_:8911:101) `Rated primary voltage` = 400.000 kV

The `Rated primary voltage` parameter is used to set the primary rated voltage of the voltage transformer.

Parameter: Rated secondary voltage

- Default setting (_:8911:102) `Rated secondary voltage` = 100 V

The `Rated secondary voltage` parameter is used to set the secondary rated voltage of the voltage transformer.

Parameter: Matching ratio Vph / VN

- Default setting (_:8911:103) `Matching ratio Vph / VN` = 1.73

With the parameter `Matching ratio Vph / VN`, you set the deviation between the calculated zero-sequence voltage and the residual voltage measured directly via a measuring input. The different transmission ratio of the voltage transformers is the cause for the deviation (see Figure 6-2).

The `Matching ratio Vph / VN` is equal to the ratio $3V_{0,sec}/V_{N,sec}$

with

$V_{0,sec}$ Calculated zero-sequence voltage

$V_{N,sec}$ Measured residual voltage

The zero voltage is calculated via phase-to-ground voltages. The residual voltage is measured on the open delta winding of the voltage transformer. For 1-phase voltage transformers, the residual voltage is measured in the generator or the transformer neutral point.

> **NOTE**
>
> The measurement residual voltage $V_{N,sec}$ is converted to a zero-sequence voltage in the device as follows:
>
> $$V_{0,sec} = V_{N,sec} \cdot \frac{\text{Matching ratio Vph/VN}}{3}$$

EXAMPLE 1:

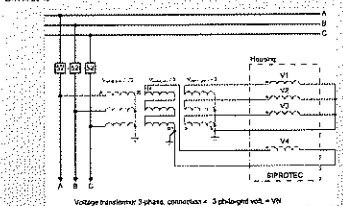

Figure 6-2 3-Phase Voltage Transformer Connection – 3 Phase-to-Ground Voltage + VN

If the connection type of the voltage transformer is `3 ph-to-gnd volt. + VN` (parameter `VT connection`) and the voltage input V4 is connected to the broken-delta winding of the voltage transformer (da/dn), the `Matching ratio Vph / VN` is as follows:

When changing the neutral point according to Figure 6-2, this results in the following values:

- The calculated secondary zero-sequence voltage $V_{0,sec}$ is equal to the secondary phase-to-ground voltage. Expressed as secondary transformer rated voltage, then $V_{rated,sec}/\sqrt{3}$.
- The measured residual voltage on the open delta winding is the sum of the voltage drops on the 3 sides. Expressed with the side ratio, the result is $V_{N,sec} = 3 V_{rated,sec}/3$.

Calculate the `Matching ratio Vph / VN` parameter as follows:

$$\text{Matching ratio } \frac{Vph}{VN} = \frac{3 \cdot V_{0,sec}}{V_{N,sec}} = \frac{3 \cdot \frac{V_{rated,sec}}{\sqrt{3}}}{3 \cdot \frac{V_{rated,sec}}{3}} = \frac{3}{\sqrt{3}} = \sqrt{3} = 1.73$$

Set `Matching ratio Vph / VN` = 1.73.

In example 1 $V_{rated,sec}$, the phase-to-ground voltage and the secondary voltage on the open delta winding were identical. If these voltages are different, use the actual numerical values in the calculation.

EXAMPLE 2:

Phase-to-ground voltage	$V_{rated,sec}$ = 100 V
Broken-delta winding (for example, grounding transformer in generator protection)	$V_{rated,sec}$ = 500 V The voltage input of the device is designed for a continuous operation using 230 V max. Therefore, the voltage on the open delta winding (500 V) is reduced to a 5:2 ratio, using an Ohmic divider. In order to calculate the matching factor, the secondary voltage of 200 V will be applied.

Calculate the `Matching ratio Vph / VN` parameter as follows:

$$\text{Matching ratio } \frac{Vph}{VN} = \frac{3 \cdot V_{0,sec}}{V_{N,sec}} = \frac{3 \cdot \frac{V_{rated,sec}}{\sqrt{3}}}{3 \cdot \frac{V_{rated,sec}}{3}} = \frac{3 \cdot \frac{100\ V}{\sqrt{3}}}{3 \cdot \frac{200\ V}{3}} = \frac{3}{2 \cdot \sqrt{3}} = \frac{\sqrt{3}}{2} = 0.866$$

Set `Matching ratio Vph / VN` = 0.866.

Interpretation of the result:

The zero-sequence voltage calculated from the phase-to-ground voltage is 57.73 V (= 100V/√3). The measured residual voltage is 200 V. The calculated adaptation factor is 0.866. The measured residual voltage is converted to a zero sequence voltage inside the device:

$$V_{0,sec} = V_{N,sec} \cdot \frac{\text{Matching ratio Vph/VN}}{3} = 200\ V \cdot \frac{0.866}{3} = 57.73\ V$$

> **NOTE**
>
> During the ground-fault test, the set adaptation factor can be checked by comparing the operational measured values. The operational measured values contain the calculated zero-sequence voltage $V_{0,sec}$ and the measured residual voltage $V_{N,sec}$. Proceed with the compilation as follows:
>
> $$\text{Matching ratio } \frac{Vph}{VN} = \frac{3 \cdot V_{0,sec}}{V_{N,sec}}$$

The `Matching ratio Vph / VN` parameter is significant for the following functions:

- Overvoltage protection with zero sequence voltage/residual voltage
- Measured-value supervision
- Scaling of the faulty and measured values

Parameter: VT connection

- Default setting (_:8911:104) `VT connection` = `3 ph-to-gnd volt. + VN`

The parameter `VT connection` shows the connection type of the voltage transformer for the 3-phase voltage measuring point. The parameter can be found in the DIGSI 5 project tree under Name of the device → Settings → Power-system data → Measuring point V 3-phase. You cannot change the connection type of the voltage transformer in the power system data.

You can change the connection type of the voltage transformer only under measuring point routing in DIGSI 5. Under Name of the device → Measuring-points routing → Voltage measuring points, select the desired connection type under Connection type. The following types of connections are possible:

- `3 ph-to-gnd volt. + VN`
- `3 ph-to-gnd voltages`
- `3 ph-to-ph volt. + VN`
- `3 ph-to-ph voltages`
- `2 ph-to-ph volt. + VN`
- `2 ph-to-ph voltages`
- `2 ph-to-gnd volt. + VN`
- `2 ph-to-gnd voltages`

Depending on the connection type selected, you must route the measured values to the terminals of the voltage measuring point in DIGSI 5. You can find connection examples for voltage transformers in the chapters

A.8 Connection Examples for Voltage Transformers for 7SJ85 and *A.9 Connection Examples for Voltage Transformers for 7SJ82*. The connection examples provide assistance when selecting the type of connection.

Parameter: Inverted phases

- Default setting (_:8911:106) `Inverted phases` = `none`

The `Inverted phases` parameter is intended for special applications, for example, pumped-storage hydropower plants (see chapter Phase-rotation reversal). This default setting may be retained for power-system protection applications.

Parameter: Tracking

- Default setting (_:8911:111) `Tracking` = `active`

The `Tracking` parameter is used to determine whether the measuring channels of this measuring point shall be used to determine the sampling frequency.

The sampling frequency of the device is adjusted to the power frequency. The device selects a measuring channel, through which the sampling frequency is determined. Preferably, this should be a voltage metering channel. The validity of the signal is monitored (minimum level, frequency range). If these values are invalid, the device switches to another channel (etc.). Once switched to a current channel, the system automatically switches back to this channel if a voltage channel is valid again.

Parameter Value	Description
`active`	If the parameter `Tracking` = `active` has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. Note: If the parameter `Tracking` = `active`, the determined sampling frequency applies to all functions in the device that do not use fixed sampling rates.
`inactive`	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value `inactive`.

Parameter: Magnitude correction

- Default setting (_:8911:103) `Magnitude correction` = 1.000

When using the `Magnitude correction` parameter, the magnitude (magnitude correction) is adjusted for the voltage input. This allows you to correct the tolerances of the primary current transformer phase-selectively. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.

> **NOTE**
>
> The `Magnitude correction` parameter has nothing to do with the internal adjustment of the input circuit.

6.1.5 Application and Setting Notes for Measuring Point Current 3-Phase (I-3ph)

The following example describes the settings for the current Measuring point I 3-ph (Current 3 phase). The supervision function settings are also located in the current measuring point. The description of these settings can be found in chapter 9 Supervision Functions

Parameter: CT connection

- Default setting (_:8881:115) `CT connection` = `3-phase + IN-separate`

The parameter `CT connection` shows the connection type of the current transformer for the 3-phase current measuring point. The parameter can be found in the DIGSI 5 project tree under Name of the device → Settings → Power-system data → Measuring point I 3-phase. You cannot change the connection type of the current transformer in the Power-system data.

You can change the connection type of the current transformer only under measuring point routing in DIGSI 5. Under Name of the device → Measuring point routing → Current measuring points, select the desired connection type under Connection type. The following types of connections are possible:

- `3-phase + IN-separate`
- `3-phase + IN`
- `3-phase`
- `3-phase, 2 primary CT`
- `3ph, 2prim.CT + IN-sep`
- `2ph, 2p. CT + IN-sep`

Depending on the connection type selected, you must route the measured values to the terminals of the current measuring point in DIGSI 5. You can find connection examples for current transformers in chapter *A.7 Connection Examples for Current Transformers*. The connection examples provide assistance when selecting the type of connection.

Parameter: Tracking

- Default setting (_:8881:127) `Tracking` = `active`

With the parameter `Tracking`, you specify whether you would like to work with the sampling-frequency tracking function.

Parameter Value	Description
`active`	If the parameter `Tracking` = `active` has been set, the measuring point will be included when determining the sampling frequency. If possible, only the 3-phase measuring points shall be considered. Siemens recommends using the default setting. Note: If the parameter `Tracking` = `active`, the determined sampling frequency applies to all functions in the device not using fixed sampling rates.
`inactive`	If the channels of the measuring point are not to be considered for determining the sampling frequency, please select the setting value `inactive`.

Parameter: Rated primary current

- Default setting (_:8881:101) `Rated primary current` = 1000 A

With the `Rated primary current` parameter, the active rated primary current of the current transformer is set.

Parameter: Rated secondary current

- Default setting (_:8881:102) `Rated secondary current` = 1 A

With the `Rated secondary current` parameter, you set the current rated secondary current of the current transformer.

Parameter: Current range

- Default setting 7SJ82 (_:8881:117) `Current range` = 50 x IR
- Default setting 7SJ85 (_:8881:117) `Current range` = 100 x IR

The `Current range` parameter allows you to set the dynamic range for the current input. Please retain the default setting for power-system protection applications. The current measuring range 1.6 x rated applies for the connection type `3-phase + IN-separate` and the sensitive current input for the measuring inputs.

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Parameter: Neutr.point in dir.of ref.obj

- Default setting (_:8881:116) Neutr.point in dir.of ref.obj = yes

The Neutr.point in dir.of ref.obj parameter is used to set the direction of the neutral point of the current transformer (see following figure). Often, the neutral point of the current transformer is determined by the direction of the protected object (for example, in the direction of the line, cable, transformer). For this reason, the default setting of the parameter was defined as yes.

When switching the parameter, the direction of the phase currents and of the ground current IN or IN sensitive is rotated device-internally.

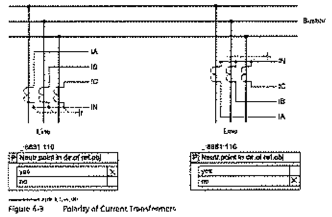

Figure 6-9 Polarity of Current Transformers

Parameter: Inverted phases

- Default setting (_:8881:114) Inverted phases = none

The Inverted phases parameter is intended for special applications, for example, pumped reservoir plants (see Chapter Phase-rotation reversal). This default setting may be retained for power-system protection applications.

Parameter: Magnitude correction

- Default setting (_:3841:103) Magnitude correction = 1.000

When using the Magnitude correction parameter, you adjust the amplitude (amplitude correction) for the current input. This allows you to correct the tolerances of the primary current transformer phase selectively. The magnitude correction may be required for highly precise measurements. Use a comparison measurement to determine the setting value (for example, a high-precision measuring-voltage transformer). If a primary correction is not necessary, retain the default setting.

> **NOTE**
>
> The Magnitude correction parameter has nothing to do with the internal adjustment of the input circuit.

Note Regarding Routable Data

Indications for the current rotating field and the information pertaining to the sampling-frequency tracking can be found in information routing under Power-system data → General in DIGSI 5. The indication Freq.out of oper.range means that the frequency operating range has been exceeded. Either the

frequency is out of range (10 Hz to 80 Hz) or the input signals are too small for a manual update. Should this condition occur, the system switches the update frequency to a sampling rate that corresponds to the rated frequency.

Furthermore, there are 2 additional measured frequency values available. The measured value f sys displays the current system frequency, and the measured value f track displays the sampling frequency currently set. Siemens recommends routing both measured values in fault-recording channel.

6.1.6 Settings

General Information

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Phase sequence		• ABC • ACB	ABC

Measuring Point I-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:2311:102	General:Rated secondary current		• 1 A • 5 A	1 A
_:2311:103	General:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:2311:104	General:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:2311:116	General:Term. 1,3,5,7 in dir. of obj.		• no • yes	yes
_:2311:105	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring-point ID		0 to 100	0
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• IA • IB • IC • IN • INsens • Ix	

Measuring Point I-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8881:115	CT 3-phase:CT connection		• not assigned • 3-phase + IN • 3-phase • 3-phase + IN separate • 3-phase, 2 primary CT • 1ph,2prim CT + IN-sep • 2ph, 2p. CT + IN-sep	3-phase + IN
_:8881:127	CT 3-phase:Tracking		• inactive • active	active
_:8881:130	CT 3-phase:Measuring point ID		0 to 100	0
CT phases				
_:8881:101	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:102	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:117	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:118	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
_:8881:116	CT 3-phase:Neutr.point in dir.of ref.obj		• no • yes	yes
_:8881:114	CT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8881:107	CT 3-phase:CT error changeover		1.00 to 10.00	1.00
_:8881:108	CT 3-phase:CT error A		0.5 % to 50.0 %	5.0 %
_:8881:109	CT 3-phase:CT error B		0.5 % to 50.0 %	15.0 %
CT IN				
_:8881:104	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:105	CT 3-phase:Rated secondary current		• 1 A • 5 A	1 A
_:8881:119	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	100 x IR
_:8881:120	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
CT IN2				
_:8881:106	CT 3-phase:Rated primary current		1.0 A to 100000.0 A	1000.0 A
_:8881:113	CT 3-phase:Rated secondary current		1 A to 5 A	1 A

Addr.	Parameter	C	Setting Options	Default Setting
_:8881:121	CT 3-phase:Current range		• 1.6 x IR • 100 x IR • 50 x IR	1.6 x IR
_:8881:122	CT 3-phase:Internal CT type		• CT protection • CT measurement • CT Process bus	CT protection
CT 1				
_:3841:103	CT 1:Magnitude correction		0.010 to 10.000	1.000
_:3841:117	CT 1:Phase		• IA • IB • IC • IN • INsens • Ix	
CT 2				
_:3842:103	CT 2:Magnitude correction		0.010 to 10.000	1.000
_:3842:117	CT 2:Phase		• IA • IB • IC • IN • INsens • Ix	
CT 3				
_:3843:103	CT 3:Magnitude correction		0.010 to 10.000	1.000
_:3843:117	CT 3:Phase		• IA • IB • IC • IN • INsens • Ix	
CT 4				
_:3844:103	CT 4:Magnitude correction		0.010 to 10.000	1.000
_:3844:117	CT 4:Phase		• IA • IB • IC • IN • INsens • Ix	
Brk.wire det.				
_:5581:1	Brk.wire det.:Mode		• off • on • test	off
Supv. balan. I				
_:2491:1	Supv. balan. I:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2491:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:2491:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:2491:6	Supv. balan. I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. ph.seq.I				
_:2551:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:2551:6	Supv. ph.seq.I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. sum I				
_:2431:1	Supv. sum I:Mode		• off • on • test	off
_:2431:102	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
_:2431:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:2431:6	Supv. sum I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv.ADC sum I				
_:2401:1	Supv.ADC sum I:Mode		• off • on • test	off

Measuring Point V-1ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Rated primary voltage		0.200 kV to 1200.000 kV	400.000 kV
_:2311:102	General:Rated secondary voltage		80 V to 340 V	100 V
_:2311:103	General:Tracking		• inactive • active	inactive
_:2311:130	General:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000

Addr.	Parameter	C	Setting Options	Default Setting
_:3811:108	VT 1:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB •	
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

Measuring Point V-3ph

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:8911:101	VT 3-phase:Rated primary voltage		0.200 kV to 1200.000 kV	400.000 kV
_:8911:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:8911:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:8911:104	VT 3-phase:VT connection		• not assigned • 3 ph-to-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages • 2 ph-to-ph volt. + VN • 2 ph-to-ph voltages	3 ph-to-gnd volt. + VN
_:8911:106	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:8911:111	VT 3-phase:Tracking		• inactive • active	active
_:8911:130	VT 3-phase:Measuring-point ID		0 to 100	0
VT 1				
_:3811:103	VT 1:Magnitude correction		0.010 to 10.000	1.000
_:3811:108	VT 1:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB	

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Addr.	Parameter	C	Setting Options	Default Setting
_:3811:107	VT 1:Sequence number device		1 to 2147483647	2147483647
VT 2				
_:3812:103	VT 2:Magnitude correction		0.010 to 10.000	1.000
_:3812:108	VT 2:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB	
_:3812:107	VT 2:Sequence number device		1 to 2147483647	2147483647
VT 3				
_:3813:103	VT 3:Magnitude correction		0.010 to 10.000	1.000
_:3813:108	VT 3:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB •	
_:3813:107	VT 3:Sequence number device		1 to 2147483647	2147483647
VT 4				
_:3814:103	VT 4:Magnitude correction		0.010 to 10.000	1.000
_:3814:108	VT 4:Phase		• VA • VB • VC • VAB • VBC • VCA • VN • Vx • VCB •	
_:3814:107	VT 4:Sequence number device		1 to 2147483647	2147483647
Supv. balan. V				
_:2521:1	Supv. balan. V:Mode		• off • on • test	off
_:2521:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:2521:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75

Addr.	Parameter	C	Setting Options	Default Setting
_:2521:6	Supv. balan. V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. ph.seq.V				
_:2581:1	Supv. ph.seq.V:Mode		• off • on • test	off
_:2581:6	Supv. ph.seq.V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
Supv. sum V				
_:2461:1	Supv. sum V:Mode		• off • on • test	off
_:2461:3	Supv. sum V:Threshold		0.300 V to 170.000 V	25.000 V
_:2461:6	Supv. sum V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s
VT miniatureCB				
_:2641:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

6.1.7 Information List

General

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Phs-rotation reversal	SPS	I
_:2311:501	General:>Invert Phases	SPS	I
General			
_:2311:319	General:Phase sequence ABC	SPS	O
_:2311:320	General:Phase sequence ACB	SPS	O
_:2311:321	General:Freq.out of oper.range	SPS	O
_:2311:322	General:f sys	MV	O
_:2311:323	General:f track	MV	O

Measuring Point I-1ph

No.	Information	Data Class (Type)	Type
CT 1			
_:3841:300	CT 1:Sampled val. current	SAV	O

Measuring Point I-3ph

No.	Information	Data Class (Type)	Type
General			
_:8881:319	CT 3-phase:Phases AB inverted	SPS	O
_:8881:320	CT 3-phase:Phases BC inverted	SPS	O
_:8881:321	CT 3-phase:Phases AC inverted	SPS	O

No.	Information	Data Class (Type)	Type
CT 1			
_:3811:300	CT 1:Sampled val. current	SAV	O
CT 2			
_:3812:300	CT 2:Sampled val. current	SAV	O
CT 3			
_:3813:300	CT 3:Sampled val. current	SAV	O
CT 4			
_:3814:300	CT 4:Sampled val. current	SAV	O
Brk.wire det.			
_:5581:82	Brk.wire det.:>Block function	SPS	I
_:5581:54	Brk.wire det.:Inactive	SPS	O
_:5581:52	Brk.wire det.:Behavior	ENS	O
_:5581:53	Brk.wire det.:Health	ENS	O
_:5581:301	Brk.wire det.:Phs A BW suspected	SPS	O
_:5581:302	Brk.wire det.:Phs B BW suspected	SPS	O
_:5581:303	Brk.wire det.:Phs C BW suspected	SPS	O
_:5581:304	Brk.wire det.:Phase A broken wire	SPS	O
_:5581:305	Brk.wire det.:Phase B broken wire	SPS	O
_:5581:306	Brk.wire det.:Phase C broken wire	SPS	O
_:5581:307	Brk.wire det.:Broken wire suspected	SPS	O
_:5581:308	Brk.wire det.:Broken wire confirmed	SPS	O
Supv. balan. I			
_:2491:82	Supv. balan. I:>Block function	SPS	I
_:2491:54	Supv. balan. I:Inactive	SPS	O
_:2491:52	Supv. balan. I:Behavior	ENS	O
_:2491:53	Supv. balan. I:Health	ENS	O
_:2491:71	Supv. balan. I:Failure	SPS	O
Supv. ph.seq.I			
_:2551:82	Supv. ph.seq.I:>Block function	SPS	I
_:2551:54	Supv. ph.seq.I:Inactive	SPS	O
_:2551:52	Supv. ph.seq.I:Behavior	ENS	O
_:2551:53	Supv. ph.seq.I:Health	ENS	O
_:2551:71	Supv. ph.seq.I:Failure	SPS	O
Supv. sum I			
_:2431:82	Supv. sum I:>Block function	SPS	I
_:2431:54	Supv. sum I:Inactive	SPS	O
_:2431:52	Supv. sum I:Behavior	ENS	O
_:2431:53	Supv. sum I:Health	ENS	O
_:2431:71	Supv. sum I:Failure	SPS	O
Supv.ADC sum I			
_:2401:82	Supv.ADC sum I:>Block function	SPS	I
_:2401:54	Supv.ADC sum I:Inactive	SPS	O
_:2401:52	Supv.ADC sum I:Behavior	ENS	O
_:2401:53	Supv.ADC sum I:Health	ENS	O
_:2401:71	Supv.ADC sum I:Failure	SPS	O

Measuring Point V-1ph

No.	Information	Data Class (Type)	Type
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
DefinitecT 1			
_:2641:500	VT miniatureCB:>Open	SPS	I

Measuring Point V-3ph

No.	Information	Data Class (Type)	Type
General			
_:8911:315	VT 3-phase:Phases AB inverted	SPS	O
_:8911:316	VT 3-phase:Phases BC inverted	SPS	O
_:8911:317	VT 3-phase:Phases AC inverted	SPS	O
VT 1			
_:3811:300	VT 1:Sampled val. voltage	SAV	O
VT 2			
_:3812:300	VT 2:Sampled val. voltage	SAV	O
VT 3			
_:3813:300	VT 3:Sampled val. voltage	SAV	O
VT 4			
_:3814:300	VT 4:Sampled val. voltage	SAV	O
Supv. balan. V			
_:2521:82	Supv. balan. V:>Block function	SPS	I
_:2521:54	Supv. balan. V:Inactive	SPS	O
_:2521:52	Supv. balan. V:Behavior	ENS	O
_:2521:53	Supv. balan. V:Health	ENS	O
_:2521:71	Supv. balan. V:Failure	SPS	O
Supv. ph.seq.V			
_:2581:82	Supv. ph.seq.V:>Block function	SPS	I
_:2581:54	Supv. ph.seq.V:Inactive	SPS	O
_:2581:52	Supv. ph.seq.V:Behavior	ENS	O
_:2581:53	Supv. ph.seq.V:Health	ENS	O
_:2581:71	Supv. ph.seq.V:Failure	SPS	O
Supv. sum V			
_:2461:82	Supv. sum V:>Block function	SPS	I
_:2461:54	Supv. sum V:Inactive	SPS	O
_:2461:52	Supv. sum V:Behavior	ENS	O
_:2461:53	Supv. sum V:Health	ENS	O
_:2461:71	Supv. sum V:Failure	SPS	O
DefinitecT 1			
_:2641:500	VT miniatureCB >Open	SPS	I

6.2 Group Indications of Overcurrent Protection Functions

6.2.1 Description

The function block Group Indications of the overcurrent protection functions uses the pickup and operate indications of the following functions:

- Overcurrent Protection, Phases
- Overcurrent Protection, Ground
- Directional time-overcurrent protection, phases
- Directional Overcurrent Protection, Ground
- Instantaneous High-Current Tripping

The group indications of the overcurrent protection are generated by a logical OR of the stage-selective pickup and operate indications of the functions listed above (see also Figure 6-4):

- Pickup
- Operate

The pickup and operate indications are output, where present, with direction information.

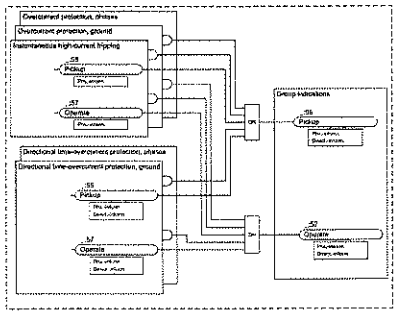

Figure 6-4 Logic Diagram of the Overcurrent Protection Group Indications

6.3 Overcurrent Protection, Phases

6.3.1 Overview of Functions

The **Overcurrent protection, phases** function (ANSI 50/51):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.3.2 Structure of the Function

The **Overcurrent protection, phases** function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, phases – advanced** (50/51 OC-3ph-A)
- **Overcurrent protection, phases – basic** (50/51 OC-3ph-B)

The Basic function type is provided for standard applications. The Advanced function type offers more functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the **Overcurrent protection, phase– advanced** function type, the following stages can be operated simultaneously:

- **Maximum of 4 stages Definite time-overcurrent protection – advanced**
- **2 stages Inverse time-overcurrent protection – advanced**
- **2 stages User-defined overcurrent protection characteristic curve**

In the **Overcurrent protection, phases – basic** function type, the following stages can be operated simultaneously:

- **Maximum of 4 stages Definite time-overcurrent protection – basic**
- **1 stage Inverse time-overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The optional function block Filter offered in the advanced function allows to gain harmonics or to compensate the amplitude attenuation for the RMS value.

The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- Pickup
- Operate

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