Addr.	Parameter	C	Setting Options	Default Setting
_.11	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_.113	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.set: bin. input				
_.34	Log.-inv.-T #:Effected by binary input		• no • yes	no
_.41	Log.-inv.-T #:Stage blocked		• no • yes	no
_.119	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_.112	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s

6.21.7.4 Information List

No.	Information	Data Class (Type)	Type
Log.-inv.-T #			
_.81	Log.-inv.-T #:Block stage		I
_.501	Log.-inv.-T #:Release delay & op.		I
_.84	Log.-inv.-T #:Activ. dyn. settings		I
_.500	Log.-inv.-T #:Block delay & op.		I
_.54	Log.-inv.-T #:Inactive		O
_.52	Log.-inv.-T #:Behavior		O
_.53	Log.-inv.-T #:Health		O
_.60	Log.-inv.-T #:Inrush blocks operate		O
_.62	Log.-inv.-T #:Dyn.set. AR cycle1act.		O
_.63	Log.-inv.-T #:Dyn.set. AR cycle2act.		O
_.64	Log.-inv.-T #:Dyn.set. AR cycle3act.		O
_.65	Log.-inv.-T #:Dyn.set. ARcycle>3act		O
_.66	Log.-inv.-T #:Dyn.set. CLP active		O
_.67	Log.-inv.-T #:Dyn.set. BI active		O
_.68	Log.-inv.-T #:Dyn. set. blks. pickup		O
_.55	Log.-inv.-T #:Pickup		O
_.300	Log.-inv.-T #:Direction		O
_.56	Log.-inv.-T #:Operate delay expired		O
_.57	Log.-inv.-T #:Operate		O

6.21.8 Stage Description Knee-Point Characteristic Curve

6.21.8.1 Description

Logic of the Stage

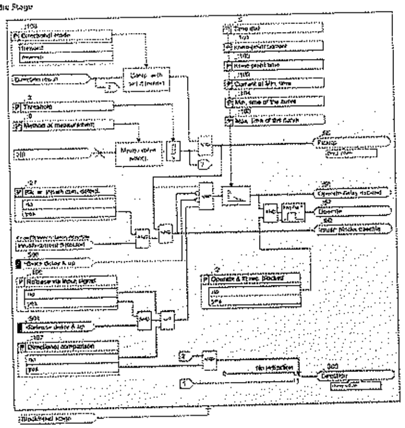

Figure 6-318 Logic Diagram of the Directional Logarithmic Inverse Time with Knee Point Overcurrent Protection, Ground

Apart from the operate curve, this type of stage is almost identical to the **inverse time-overcurrent protection – advanced stage** (see chapter 6.21.6.1 Description). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 6.21.6.1 Description.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the threshold value. An integrator accumulates the value $1/T_{op}$. If the accumulated integral reaches the fixed value 1, the stage operates.

The curve used to calculate the time value T_{op} is shown in the following graphic. The curve is composed of 2 sections with different slope. 7 parameters are used to define the logarithmic inverse time with knee point characteristic curve. The parameter Max. time of the curve determines the initial time value of the characteristic curve and relates to the 20 Threshold value. The transition point is defined by parameter Knee-point current and parameter Knee-point time. The parameter Min. time of the curve indicates the lower time limit, and parameter Current at Min. time determines the current value at Min. time of the curve. The parameter Time dial serves as a time factor to the operate time.

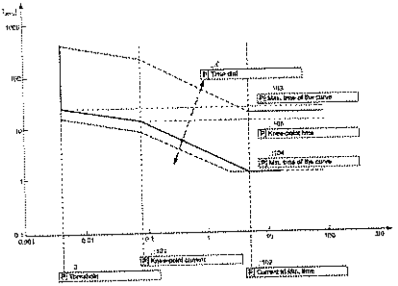

Figure 6-319 Operate Curve of the Logarithmic Inverse Time with Knee Point Characteristic (in the Example of Threshold = 0.004 A)

6.21.8.2 Application and Setting Notes

Apart from the operate curve, this type of stage is almost identical to the **inverse time-overcurrent protection – advanced stage** (see chapter 6.21.6.1 Description). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 6.21.6.2 Application and Setting Notes.

Parameter: Threshold

- Default setting (_:3) Threshold = 1.20 A

You can use the Threshold parameter to define the pickup value of the stage corresponding to the specific application.

Parameter: Time dial

- Default setting (_:6) Time dial = 0.2

You can use the Time dial parameter to displace the operate curve in the time direction.
General information cannot be provided. Define the value corresponding to the application.

Parameter: Knee-point

- Default setting (_:101) Knee-point current = 1.300 A
- Default setting (_:105) Knee-point time = 23.60 s

You use the Knee-point current parameter and the Knee-point time parameter to define the knee-point of the operate curve.
General information cannot be provided. Define the values corresponding to the application.

Parameter: Minimum Time of the Operate Curve

- Default setting (_:104) Min. time of the curve = 0.80 s
- Default setting (_:102) Current at Min. time = 1.500 A

Via the parameters Min. time of the curve and Current at Min. time, the point of the operate curve is defined where higher currents do no longer cause shorter operate times.
General information cannot be provided. Define the value corresponding to the application.

Parameter: Maximum Time of the Operate Curve

- Default setting (_:103) Max. time of the curve = 23.00 s

You can use the parameter Max. time of the curve to determine the initial value of the operate curve (for 3I0 = Threshold).
General information cannot be provided. Define the value corresponding to the application.

6.21.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_.1	Log.inv.T KP #:Mode		• off • on • test	off
_.2	Log.inv.T KP #:Operate & flt.rec. blocked		• no • yes	no
_.108	Log.inv.T KP #:Directional mode		• forward • reverse	forward
_.8	Log.inv.T KP #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_.107	Log.inv.T KP #:Directional comparison		• no • yes	no
_.106	Log.inv.T KP #:Release via input signal		• no • yes	no
_.10	Log.inv.T KP #:Blk. by meas.-volt. failure		• no • yes	yes
_.27	Log.inv.T KP #:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_.11	Log.inv.T KP #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_.109	Log.inv.T KP #:Time dial		0.05 to 1.50	0.20
_.101	Log.inv.T KP #:Knee-point current	1 A @ 100 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.300 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.300 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.500 A
_.105	Log.inv.T KP #:Knee-point time		0.00 s to 100.00 s	23.60 s
_.102	Log.inv.T KP #:Current at Min. time	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_.104	Log.inv.T KP #:Min. time of the curve		0.00 s to 30.00 s	0.80 s
_.103	Log.inv.T KP #:Max. time of the curve		0.00 s to 200.00 s	93.00 s

6.21.8.4 Information List

No.	Information	Data Class (Type)	Type
Log.inv.T KP #			
_.81	Log.inv.T KP #:Block stage	SPS	I
_.501	Log.inv.T KP #:Release delay & op.	SPS	I
_.500	Log.inv.T KP #:Block delay & op.	SPS	I
_.54	Log.inv.T KP #:Inactive	SPS	O
_.52	Log.inv.T KP #:Behavior	ENS	O
_.53	Log.inv.T KP #:Health	ENS	O
_.60	Log.inv.T KP #:Inrush blocks operate	SPS	O
_.55	Log.inv.T KP #:Pickup	ACD	O
_.300	Log.inv.T KP #:Direction	ACD	O
_.56	Log.inv.T KP #:Operate delay expired	ACT	O
_.57	Log.inv.T KP #:Operate	ACT	O

6.21.9 Stage with User-Defined Characteristic Curve

6.21.9.1 Description

Logic of the Stage

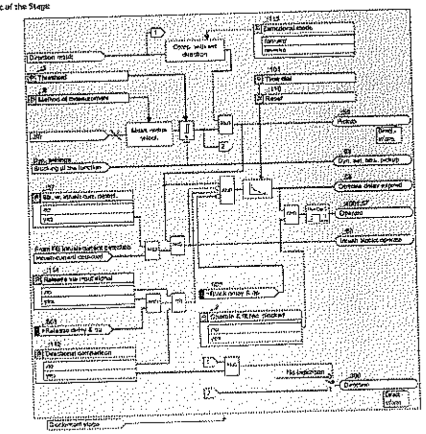

Figure 6-320 Logic Diagram of the Directional User-Defined Characteristic Curve Overcurrent Protection, Ground

This stage is structured in the same way as the inverse time-overcurrent protection – advanced stage (see chapter 6.21.6.1 Description). The only difference is that you can define the characteristic curve.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 6.21.6.1 Description.

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User-Defined Characteristic Curve

With the directional, user-defined characteristic curve, you can define the operate curve point by point using up to 30 value pairs of current and time. The device uses linear interpolation to calculate the characteristic curve from these values. You can also define a dropout characteristic curve if you wish.

Pickup and Dropout Behavior with User-Defined Characteristic Curves

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the threshold value by a factor of 1.045 (0.95 · 1.1 · threshold value), the dropout is started. The pickup will be indicated as outgoing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is started from 0.9 of the set threshold value.

The following figure shows the pickup behavior and dropout behavior when a directional user-defined characteristic curve is used.

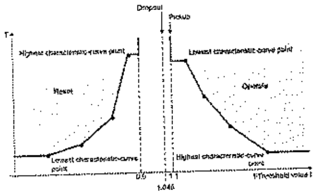

Figure 6-321 Pickup and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

Note that the currents that are lower than the current value of the smallest characteristic-curve point do not extend the operate time. The pickup characteristic runs in parallel to the current axis up to the smallest characteristic curve point. Currents that are larger than the current value of the largest characteristic-curve point do not reduce the operate time. The pickup characteristic runs in parallel to the current axis from the largest characteristic-curve point.

6.21.9.2 Application and Setting Notes

This stage is structured in the same way as the **Inverse time-overcurrent protection – advanced stage**. The only difference is that you can define the characteristic curve as required. This section only provides application and setting notes for setting the characteristic curves. For guidance on the other parameters of the stage, see chapter 6.21.6.2 Application and Setting Notes.

Parameter: Current/time value pairs (of the Operate Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic curve point. The setting depends on the characteristic curve you want to realize.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold setting afterwards if you want to displace the characteristic curve.

Specify the time value in seconds. The characteristic curve is displaced using the Time dial parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

- Default setting (_:101) Time dial = 1

You can use the Time dial parameter to displace the characteristic curve in the time direction.

The setting value for the Time dial parameter is derived from the time-grading chart that has been prepared for the system. Where no grading and therefore no displacement of the characteristic curve is required, leave the Time dial set to 1.

Parameter: Reset

- Default setting (_:110) Reset = disk emulation

The Reset parameter is used to define whether the stage drops out according to the dropout characteristic curve (behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Both operate curve and a dropout characteristic curve have to be specified with this setting. Use this setting if the device is coordinated with electromechanical devices or other devices performing dropout after disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation, that is, if instantaneous dropout is required.

Parameter: Current/time value pairs (of the Dropout Curve)

Use these settings to define the characteristic curve. Set a current/time value pair for each characteristic curve point. The setting is determined by the characteristic curve you want to achieve.

Set the current value as a multiple of the threshold value. Siemens recommends that you set the Threshold parameter to 1.00 in order to obtain a simple relation. You can change the threshold setting afterwards if you want to displace the characteristic curve.

Specify the time value in seconds. The characteristic curve is displaced using the Time dial parameter.

NOTE

The value pairs must be entered in continuous order.

6.21.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off

Addr.	Parameter	C	Setting Options	Default Setting
_:2	User curve #:Inrush & Curr. limited		• no • yes	no
_:113	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Direct.det. confirmation		• no • yes	no
_:114	User curve #:Include ext. input signal		• no • yes	no
_:14	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.21.9.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	SPS	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:300	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.21.10 Influence of Other Functions via Dynamic Settings

6.21.4.1 Description and 6.21.4.2 Application and Setting Notes (Advanced Stage) describe the influence of other functions on dynamic settings.

6.22 Group Indications of Overcurrent Protection Functions

6.22.1 Description

The function block Group indications of the overcurrent protection functions uses the pickup and operate indications of the following functions:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Directional time-overcurrent protection, phases
- Directional overcurrent protection, ground
- Ground-fault protection for high-resistance ground faults in grounded systems
- Instantaneous high-current tripping

The group indications of the overcurrent protection are generated by a logical OR of the stage-selective pickup and operate indications of the functions listed above (see also Figure 6-322):

- Pickup
- Operate

The pickup and operate indications are output, where present, with direction information.

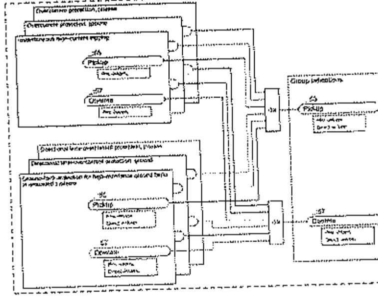

Figure 6-322 Logic Diagram of the Overcurrent Protection Group Indications

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6.23 Negative-Sequence Protection

6.23.1 Overview of Functions

The function Negative-sequence protection (ANSI 46):

- Detects 1-phase or 2-phase short circuits in the electrical power system with clearly increased sensitivity compared to the classical overcurrent protection
- Protects electric machines during excessive unbalanced load
- Reports unbalanced load conditions in the electricity supply system
- Detects phase interruptions in the primary system
- Locates short circuits or inversions in the connections to the current transformers

6.23.2 Structure of the Function

The Negative-sequence protection function is used in protection function groups with current measurement.

The function is preconfigured by the manufacturer with 2 Definite-time negative-sequence protection stages.

In the function Negative-sequence protection, the following stages can be operated simultaneously:

- 3 stages Definite-time negative sequence protection
- 2 stages Inverse-time negative-sequence protection

The stages have an identical structure. Stages that are not preconfigured are shown in gray in the following figure.

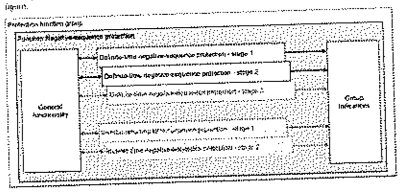

Figure 6-323 Structure/Embedding of the Function

If the device is equipped with the inrush-current detection function, the stages can be stabilized against operate due to transformer-inrush currents.

6.23.3 General Functionality

6.23.3.1 Description

Logic

The following figure represents the logic of the general functionality which applies across all configured stages. It contains:

- Selection of the reference value
- Current release criterion

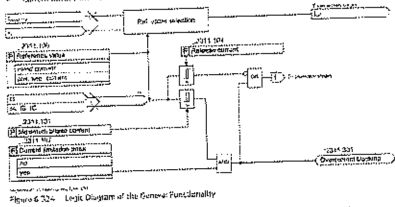

Figure 6-324 Logic Diagram of the General Functionality

(1) Switchover to I_1 with (_:2311:106) Reference value = pos. seq. current

Reference Value

With the parameter Reference value, the negative-sequence current I_2 is normalized to the rated object current $I_{rated,obj}$ or to the positive-sequence current I_1. When I_2 is normalized to I_1, the sensitivity of the function for low short-circuit currents is increased.

Current Limitation and Maximum Phase Current

With the parameters Current limitation Imax and Maximum phase current, you restrict the operating range of the function. When the limiting is activated, pickup of the stages is blocked as soon as the maximum phase-current threshold value is exceeded. For more information, refer to the stage description.

Release Current

The threshold value of the Release current serves to release the negative-sequence protection.

6.23.3.2 Application and Setting Notes

Parameter: Reference value

- Default setting (_:2311:106) Reference value = rated current

With the parameter Reference value, you define the normalization of the negative-sequence current I_2 to the rated object current $I_{rated,obj}$ ($I_2/I_{rated,obj}$) or to the positive-sequence current I_1 (I_2/I_1).

Parameter Value	Description
$I_2/I_{rated,obj}$	The negative-sequence current is referred to the rated current of the protected object. This is a preferred normalization for electrical machines, because the permissible limiting values are indicated exclusively referred to the machine rated current. You can also use this normalization for other applications.
I_2/I_1	The normalization of the negative-sequence system to the positive-sequence system yields a higher sensitivity. Use this normalization when detecting interruptions in the primary system.

Set the parameter depending on the application.

Parameter: Current limitation Imax, Maximum phase current

- Default setting (_:2311:105) Current limitation Imax = no
- Recommended setting value (_:2311:101) Maximum phase current = 10.0 A at 1 A

If the protection function needs a maximum current limitation, set the value of the Current limitation Imax parameter from no to yes. With the parameter Maximum phase current, you set the upper limit of the phase current. CT saturation will cause negative sequence current in the secondary system. To avoid overfunction due to the CT saturation, a suitable phase current limit value is 10 times of the rated protection object current.

Parameter: Release current

- Recommended setting value (_:2311:104) Release current = 0.05 A at 1 A

For the safe calculation of negative sequence currents, the current in at least one phase must be greater than 5 % of the secondary rated device current. For a 1 A device, the value of Release current is 0.05 A (0.25 A for a 5 A device).

6.23.4 Stage with Definite-Time Characteristic Curve

6.23.4.1 Stage Description

Logic of a Stage

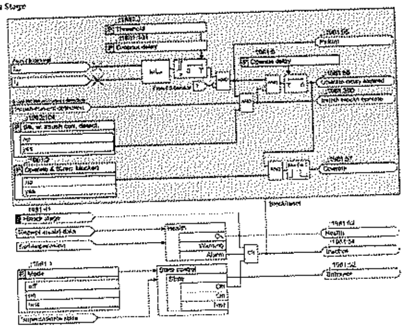

Figure 6-325 Logic Diagram of the Stage Negative-Sequence Protection with Definite-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3-phase phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the FB General.

Blocking of the Stage

When blocked, the picked up protection stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal >Block stage.

Blocking of Tripping via the Device-Internal Inrush-Current Detection Function

With the Blk. w. inrush curr. detect. parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a

corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.23.4.2 Application and Setting Notes

Parameter: Threshold

- Recommended setting value (_:1981:3) Threshold = 10 %

The setting of the parameter Threshold depends on the respective application. A threshold value of 10 % is a practicable value for fault indications of electrical machines.

Parameter: Operate delay

- Recommended setting value (_:1981:6) Operate delay = 1500 ms

The setting of the Operate delay depends on the application. Observe the time grading in the power-system protection and do not set the time for monitoring too short. The default setting is practicable. For motors, the time depends on the permissible time period for the set unbalanced load.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:1981:104) Blk. w. inrush curr. detect. = no

With the parameter Blk. w. inrush curr. detect., the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set that parameter to yes.

Backup Protection with a Three-Winding Transformer

The function Negative-sequence protection can be used for a transformer as a responsive backup protection on the supply side. It aims to acquire weak currents from the 1-phase and 2-phase short circuits. Also on the low-voltage side, 1-phase short circuits can be used, which do not create a zero-sequence system in the current on the upper-voltage side (for example in vector group Dyn).

The following example explains the achieved sensitivity. Figure 6-326 shows the example with the relevant technical data.

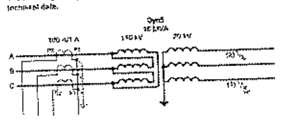

Figure 6-326 1-Phase and 2-Phase Short Circuit on Transformer

(1) 1-phase ground fault
(2) 2-phase short circuit

The standardization is based on the transformer rated object current (Reference value = rated current).

If the pickup value on the upper-voltage side is 11 % (Threshold = 11 %) of the transformer rated current, this corresponds to 0.1 A on the secondary side. With this the following currents and sensitivities are reached:

1) 1-phase short circuit

$$I_{F,1\text{-}phase} = 3 \cdot \frac{V_{US}}{V_{LS}} \cdot \frac{I_{CT,prim}}{I_{CT,S}} \cdot I_2 = 3 \cdot \frac{110\,kV}{20\,kV} \cdot \frac{100\,A}{1\,A} \cdot 0.1\,A = 165\,A$$

Sensitivity:

$$\frac{I_{F,1ph,sens}}{I_{rated,transf,LS}}[\%] = \frac{I_{F,1ph,sens}}{\frac{S_{rated,transf.}}{\sqrt{3} \cdot V_{LS}}} \cdot 100\,\% = \frac{165\,A}{\frac{16\,MVA}{\sqrt{3} \cdot 20\,kV}} \cdot 100\,\% = 36\,\%$$

b) 2-phase short circuit

$$I_{F,2ph} = \sqrt{3} \cdot \frac{V_{US}}{V_{LS}} \cdot \frac{I_{pCT}}{I_{sCT}} \cdot I_2 = \sqrt{3} \cdot \frac{110\,kV}{20\,kV} \cdot \frac{100\,A}{1\,A} \cdot 0.1\,A = 95\,A$$

Sensitivity:

$$\frac{I_{F,2ph,sens}}{I_{rated,transf,LS}}[\%] = \frac{I_{F,2ph,sens}}{\frac{S_{rated,transf.}}{\sqrt{3} \cdot V_{LS}}} \cdot 100\,\% = \frac{95\,A}{\frac{16\,MVA}{\sqrt{3} \cdot 20\,kV}} \cdot 100\,\% = 21\,\%$$

Since this is the short circuit on the low-voltage side, the time delay must be coordinated with the times of subordinate protection devices.

Line or Cable Networks

In line or cable networks, the function Negative-sequence protection is used to detect weak current caused by unbalanced faults. In the unbalanced fault, the pickup values of the overcurrent protection is not reached by unbalanced loads. As the unbalanced fault, the pickup values of the overcurrent protection is not reached.

The current is based on the rated object current (Reference value = rated current).

Therefore:

The 2-phase short circuit with the current I leads to a negative-sequence current:

$$I_2 = \frac{1}{\sqrt{3}} \cdot I = 0.58 \cdot I$$

The 1-phase short circuit with the current I leads to a negative-sequence current:

$$I_2 = \frac{1}{3} \cdot I = 0.33 \cdot I$$

If the protection works exclusively with short circuits, the protection must be set via the value for 2-phase operation. Then a 2-phase short circuit can be assumed with more than 60 % of the rated object current. Set the standardization on the rated object current. To avoid overfunction with overload, Siemens recommends a pickup value of approx. 65 %. Coordinate the time delays with the network grading for phase short circuits.

Break in Primary System

To record breaks in the primary system, set standardization on I_2/I_1 (Reference value = pos. seq. current) to achieve a higher sensitivity (independence of load current). For a 1-phase break, the ratio of the negative-sequence current and the positive-sequence current can be described according to the following equation with the negative-system and zero-sequence impedance (Z_2, Z_0).

$$\frac{I_2}{I_1} = \frac{1}{1 + \frac{\sum Z_2}{\sum Z_0}}$$

In the isolated system or with one-sided grounds, the [illegible] impedance is infinity and [illegible] ratio is [illegible]. Observe a two-sided grounded network and set the zero-sequence impedance equal to the negative-sequence impedance, then the ratio is [illegible]. If a [illegible] occurs in the secondary circuit, [illegible] possible.

For a 2-phase break, current can only flow with a two-sided grounded network. In this case, the [illegible]. If a partial 1-phase load is expected, the ratio is also set. The setting value is dependent on the maximum phase load. For a setting value of 15%, the phase current can be 30%.

If you want to prevent an indication with short circuits, activate the current limiting to, for example, 1.2 A (`Current limitation Imax = yes`, `Maximum phase current = 1.2 A at 1 A`; transformer [illegible] and [illegible] adaptation to the protected object). Here calculate the current with the current transformer ratio of the secondary circuit.

The setting of the protection stage is aligned to the network type. A setting value of 25 % (`Threshold = 25 %`) offers a sufficiently high sensitivity. If errors occur in the current transformer circuit, there can be, however, also be a tripping. To prevent over-functions during the AREC cycles, the time delay for the tripping must be set long. A time of 60 s (`Operate delay = 60.00 s`) offers sufficient reliability.

6.23.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:106	General:Reference value		• pos. seq. current • rated current	rated current
_:2311:107	General:Current limitation Imax		• no • yes	no
_:2311:101	General:Maximum phase current	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:2311:104	General:Release current	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:1981:1	Definite-T 1:Mode		• off • on • test	off
_:1981:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:1981:3	Definite-T 1:Threshold		5.0 % to 999.9 %	10.0 %
_:1981:4	Definite-T 1:Dropout ratio		0.40 to 0.99	0.95
_:1981:104	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:1981:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1981:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.50 s

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 2				
_:1982:1	Definite-T 2:Mode		• off • on • test	off
_:1982:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:1982:3	Definite-T 2:Threshold		5.0 % to 999.9 %	65.0 %
_:1982:4	Definite-T 2:Dropout ratio		0.40 to 0.99	0.95
_:1982:104	Definite-T 2:Blk. w. inrush curr. detect.		• no • yes	no
_:1982:101	Definite-T 2:Dropout delay		0.00 s to 60.00 s	0.00 s
_:1982:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.23.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:Overcurrent blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:1981:81	Definite-T 1:>Block stage	SPS	I
_:1981:52	Definite-T 1:Behavior	ENS	O
_:1981:53	Definite-T 1:Health	ENS	O
_:1981:54	Definite-T 1:Inactive	SPS	O
_:1981:56	Definite-T 1:Operate delay expired	ACT	O
_:1981:300	Definite-T 1:Inrush blocks operate	ACT	O
_:1981:55	Definite-T 1:Pickup	ACD	O
_:1981:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:1982:81	Definite-T 2:>Block stage	SPS	I
_:1982:52	Definite-T 2:Behavior	ENS	O
_:1982:53	Definite-T 2:Health	ENS	O
_:1982:54	Definite-T 2:Inactive	SPS	O
_:1982:56	Definite-T 2:Operate delay expired	ACT	O
_:1982:300	Definite-T 2:Inrush blocks operate	ACT	O
_:1982:55	Definite-T 2:Pickup	ACD	O
_:1982:57	Definite-T 2:Operate	ACT	O

6.23.5 Stage with Inverse-Time Characteristic Curve

6.23.5.1 Description

Logic of a Stage

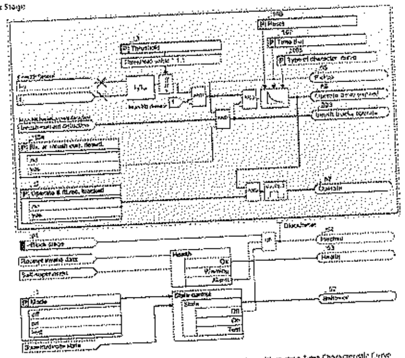

Figure 6-377 Logic Diagram of the Negative-Sequence Protection with Inverse-Time Characteristic Curve

Method of Measurement

The fundamental phasors are calculated from the 3 phase currents. Based on this, the negative-sequence system and the positive-sequence system are calculated. Following this, the negative-sequence current is normalized to the reference current. The selection of the reference current is made in the FB General.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI

When the input variable exceeds the threshold value by a factor of 1.1, the stage picks up, and the inverse-time characteristic curve is processed. An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls below the pickup value by a factor of 0.95 (0.95 · 1.1 · threshold value), the dropout is started. The pickup is indicated as clearing. You can influence the dropout behavior via setting

parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

The characteristic curve and associated formulas are shown in the Technical Data.

Blocking of the Stage

When blocked, the picked-up protection stage will drop out.

Blocking the stage is possible externally or internally via the binary input signal `>Block stage`.

Blocking of Tripping via the Device-internal Inrush-Current Detection Function

With the `Blk. w. inrush curr. detect.` parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and tripping are however blocked. The stage signals this by way of a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the tripping delay (time delay) is started. After that time, the stage operates.

6.23.5.2 Application and Settings Notes

Parameter: `Type of character. curve`

- Default setting (_:105) `Type of character. curve` = `IEC normal inverse`

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the `Type of character. curve` required for your specific application. For more information about the parameter `Type of character. curve`, refer to chapter 11.24.2 Stage with Inverse-Time Characteristic Curve.

Parameter: `Threshold`

- Recommended setting value (_:3) `Threshold` = 10.0 %

The setting of the parameter `Threshold` depends on the respective application. A threshold value of 10 % is a practicable value for fault detection for different applications.

Parameter: `Time dial`

- Recommended setting value (_:107) `Time dial` = 1.00

With the parameter `Time dial`, you displace the characteristic curve in the time direction.

The set value for the parameter `Time dial` is derived from the time grading schedule that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the `Time dial` parameter at 1.00 (default setting).

Parameter: `Reset`

- Default setting (_:106) `Reset` = `disk emulation`

With the parameter `Reset`, you define whether the stage drops out according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

Parameter Value	Description
disk emulation	Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: `Blk. w. inrush curr. detect.`

- Default setting (_:104) `Blk. w. inrush curr. detect.` = `no`

With the parameter `Blk. w. inrush curr. detect.`, the stage can be stabilized against tripping on transformer-inrush currents. If transformers are parts of the protection zones, set this parameter to `yes`.

6.23.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T 1				
_:1	Inverse-T 1:Mode		• off • on • test	off
_:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:3	Inverse-T 1:Threshold		5.0 % to 999.9 %	10.0 %
_:104	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:105	Inverse-T 1:Type of character. curve			
_:106	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:107	Inverse-T 1:Time dial		0.05 to 15.00	1.00

6.23.5.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T 1			
_:81	Inverse-T 1:>Block stage	SPS	I
_:52	Inverse-T 1:Behavior	ENS	O
_:53	Inverse-T 1:Health	ENS	O
_:54	Inverse-T 1:Inactive	SPS	O
_:56	Inverse-T 1:Operate delay expired	ACT	O
_:300	Inverse-T 1:Inrush blocks operate	ACT	O
_:59	Inverse-T 1:Disk emulation running	SPS	O
_:55	Inverse-T 1:Pickup	ACD	O
_:57	Inverse-T 1:Operate	ACT	O

6.24 Undercurrent Protection

6.24.1 Overview of Functions

The Undercurrent protection function (ANSI 37):

- Detects the going current in a feeder after the opening of the related circuit breaker
- Detects the loss of loads
- Detects and protects pumps from running idle

6.24.2 Structure of the Function

The Undercurrent protection function is used in protection function groups with current measurement. The Undercurrent protection function comes with 1 protection stage preconfigured at the factory. A maximum of 2 protection stages can be operated simultaneously in this function. The protection stages are structured identically.

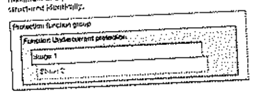

Figure 6-378 Structure/Embedding of the Function

6.24.3 Stage Description Undercurrent Protection

Logic of the Stage

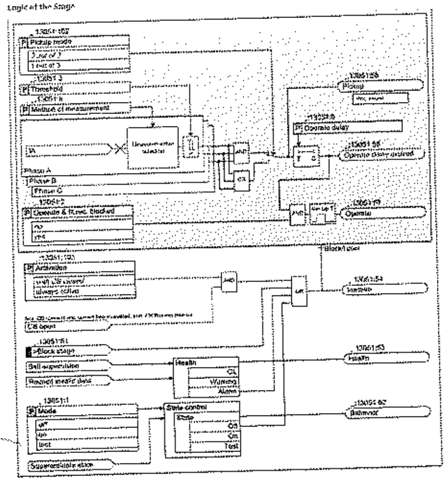

Figure 6-329 Logic Diagram of the Undercurrent Protection

Method of Measurement

You use the Method of measurement parameter to define whether the stage uses the fundamental comp. (standard method) or the calculated RMS value.

- Measurement of the fundamental comp.
  This measurement method processes the sampled current values and numerically filters out the fundamental component.
- Measurement of the parameter value RMS value
  This measurement method determines the current amplitude from the sampled values according to the definition equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

The Pickup mode parameter defines whether the protection stage picks up if all 3 measuring elements detect the undercurrent condition (3 out of 3) or if only 1 measuring element has to detect the undercurrent condition (1 out of 3).

Blocking the Stage

When blocked, the picked up protection stage will drop out. Blocking the stage is possible externally or internally via the binary input signal >Block stage.

Activation and Blocking of the Stage Depending On the Circuit Breaker Condition

With the parameter Activation, you define if the Undercurrent protection stage is always active or only active if the circuit breaker is indicating closed.
If the parameter Activation is set to with CB closed and the local circuit breaker is not closed, the function Undercurrent protection is blocked and no pickup is generated.
The circuit-breaker position is detected as closed if one of the following condition is met:

- The binary inputs are connected to the auxiliary contacts of the circuit breaker. The circuit-breaker switch position is detected as closed via the related binary inputs of the Position indication. This is also true under the condition that no phase current is flowing.
- The current-flow criterion indicates that the circuit breaker is closed. This is also true under the conditions that the auxiliary contacts indicate the circuit breaker as open.

6.24.4 Application and Setting Notes

Parameter: Activation

- Default setting (_:13081:103) Activation = with CB closed

Parameter Value	Description
with CB closed	The Undercurrent protection is active only when the circuit-breaker position is detected as closed. A precondition is, that the Position indication is routed to binary inputs to obtain the CB position information via the CB auxiliary contacts. If this is not the case, the function will always be inactive.
always active	The Undercurrent protection stage is always active independent of the position of the circuit breaker.

Parameter: Method of measurement

- Recommended setting value (_:13051:8) Method of measurement = fundamental comp.

Use the Method of measurement parameter to define whether the tripping stage uses the fundamental comp. (standard method) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient current peaks. Siemens recommends using this method as default setting.

Parameter Value	Description
RMS value	Select this measurement method if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: Pickup mode

- Default setting (_:13051:102) Pickup mode = 3 out of 3

Use the Pickup mode parameter to define whether the protection stage picks up if all 3 measuring elements detect the undercurrent condition (3 out of 3) or if only 1 measuring element has to detect the undercurrent condition (1 out of 3).

Parameter: Threshold

- Default setting (_:13051:3) Threshold = 0.050 A

Specify the Threshold (pickup threshold) for the specific application.

Parameter: Operate delay

- Default setting (_:13051:6) Operate delay = 0.05 s

Operate delay must be set according to the specific application. No general application notes can be given.

6.24.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:13051:1	Stage 1:Mode		• off • on • test	off
_:13051:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:13051:103	Stage 1:Activation		• always active • with CB closed	with CB closed
_:13051:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:13051:102	Stage 1:Pickup mode		• 1 out of 3 • 3 out of 3	3 out of 3
_:13051:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:13051:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.50 s

6.24.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

No.	Information	Data Class (Type)	Type
Stage 1			
_:13051:81	Stage 1:>Block stage	SPS	I
_:13051:54	Stage 1:Inactive	SPS	O
_:13051:52	Stage 1:Behavior	ENS	O
_:13051:53	Stage 1:Health	ENS	O
_:13051:55	Stage 1:Pickup	ACD	O
_:13051:56	Stage 1:Operate delay expired	ACT	O
_:13051:57	Stage 1:Operate	ACT	O

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6.25 Overexcitation Protection

6.25.1 Overview of Functions

The Overexcitation protection (ANSI 24) is used for detecting high induction values in generators and transformers. It protects the equipment from excessive thermal loads.
The induction is recorded indirectly by analyzing the V/f ratio (also referred to as Volt per Hertz protection). Overvoltage leads to excessive magnetizing currents, while underfrequency leads to higher losses when reversing the magnetization.
If the power system is disconnected and the voltage and frequency control function in the remaining system does not react quickly or the power imbalance is excessive, there is a risk of overexcitation.

6.25.2 Structure of the Function

The Overexcitation protection function is used within protection function groups that have a 3-phase voltage input. The function comes with the following factory-set stages:

- Thermal stage adjustable with a user-defined characteristic curve
- Definite-time stage which can be delayed using a time component

Within this function, the following maximum number of stages can be operated simultaneously: one stage with a user-defined characteristic curve and 2 definite-time stages.
The group-indication output logic (see following figure) uses the logical OR function from the stage-selective indications to generate the following group indications of the entire Overexcitation protection function:

- Pickup
- Operate indication

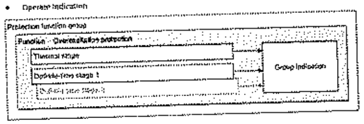

Figure 6-330 Structure/Embedding of the Function

Function Measured Value

Measured Value	Description
(_:2311:322) V/f	Value calculated by the voltage and the frequency

6.25.3 Stage with Dependent Characteristic Curve (Thermal Stage)

6.25.3.1 Protection Description

Logic

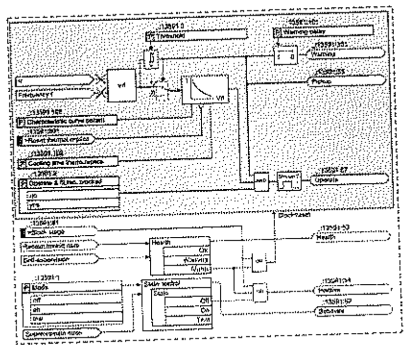

Figure 6-331 Logic of the Overexcitation Protection With Thermal Characteristic Curve

(1) Heating
(2) Cooling

V/f Method of Measurement

The input values of the protection function are the continuously measured voltage and the frequency. The phase-to-phase voltage is used to process the voltage. The angle difference method (see 6.?? Overfrequency protection) is used to determine the frequency. Both values form the V/f ratio. In order to arrive at an absolute value, standardized data is applied.
Thus, the ratio is derived from:

$$\frac{V/f_{measured}}{V_{rated}}$$

with

V Measured voltage (maximum phase-to-phase voltage)
V_{rated} Adjusted rated voltage of the protected object
f Measured frequency
f_{rated} Adjusted rated frequency

Based on the defined values, the protection function refers exclusively to primary values of the protected object. A deviation between the primary rated voltage of the voltage transformer and the protected object is corrected automatically.

NOTE
This test must be completed during a secondary test.
More information can be found in chapter 10.12 Functional Test for Overexcitation Protection.

The function compares the calculated value of the measured V/f ratio with the threshold value and the user-defined thermal characteristic curve.

Depending on the characteristic curve, a thermal trip signal is triggered after a predetermined duration.

Characteristic Curve

You can freely configure the thermal characteristic curve with the user-defined values. This provides a flexible adjustment to the specified characteristics of the protected object. If the set threshold value (parameter (_:13591:3) Threshold) is exceeded, the evaluation of the characteristic curve is initiated. Exceeding the threshold value triggers an indication (_:13591:55) Pickup. In addition, a definite-time stage may be used to generate a delayed indication output at (_:13591:301) Warning.

The pickup is used to start the integration process (weighted counting) of the thermal characteristic curve. If the time as a factor of V/f is reached, the pickup is triggered. Based on the replica of the thermal behavior, the trigger value is always 100 % (see Thermal Behavior, Page 932).

If the value drops below the pickup threshold, the trip command is rescinded and the internal counter of the parameterized cooling time (parameter (_:13591:102) Cooling time therm.replica) is reduced. The dropout threshold of the pickup threshold is fixed to 0.98 * Threshold.

A maximum of 30 overexcitation value points V/f (referring to the rated values) and operate time t can be set. The default characteristic curve refers to a standard transformer.

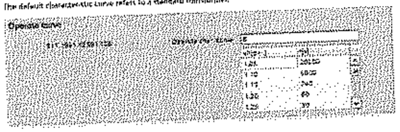

Figure 6-332 Data Sheet for Adjustment of Thermal Characteristic Curve

The parameter Threshold (pickup threshold) affects the evaluation of the characteristic curve as follows: If the Threshold is smaller than the first characteristic pair, the set time will be extended (see Figure 6-333).

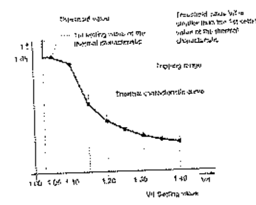

Figure 6-333 Tripping Zone of the Thermal Characteristic Curve (I)

If the Threshold is greater, then a cutoff occurs (see Figure 6-334).

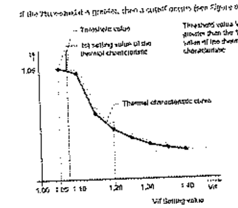

Figure 6-334 Tripping Zone of the Thermal Characteristic Curve (II)

Warning Threshold

If the Threshold is exceeded, the time delay (parameter (_:13591:101) Warning delay) is started. If the time delay has elapsed, the indication (_:13591:301) Warning will be displayed.

Thermal Behavior

The time derived from the characteristic curve and associated with the V/f value is set to 100 %. With each function call, the time will be increased according to the respective weighted integration interval. If the 100 % value is exceeded, tripping is initiated. If the V/f value is changed, the associated time from the characteristic curve is added as a new 100 % value.

In order to prevent excessive cooling times, the thermal storage has been limited internally to 150 %. The Th.rep.Val at the thermal storage will be provided as functional measured value.

Measured Value	Description
(_:13591:323) V/f th.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, the trip occurs.

Cooling Time

If the value drops below the threshold (_:13591:3) Threshold, tripping of the thermal characteristic curve (dependent characteristic curve) is revoked. However, the parameterized cooling time (Cooling time therm.replica) reduces the thermal storage (counter content) to 0. This parameter is defined as time. It is required by the thermal replica in order to cool down from 100 % to 0 %.

Resetting the Thermal Map

The binary input indication (_:13591:103) >Reset thermal rep. can be applied to reset the thermal replica. The thermal replica will then have a value of 0. A reparameterization will also lead to resetting the thermal replica.

Blocking the Stage

The function can be blocked externally or internally by the binary input signal (_:13591:81) >Block stage. Blocking will cause a picked up function to be reset.

6.25.3.2 Application and Setting Notes

Thermal overloads extended over a longer period will jeopardize electric equipment, for example, synchronous motors, generators, or transformers and may cause damage. When using the thermal, user-defined characteristic curve, the overexcitation protection lends itself perfectly for adjustment to the specified limits of the protection equipment.

The following provides the recommended settings:

NOTE
It must be noted that one requirement for the correct mode of operation of the function is based on the proper setting of the power-system data.
You can find more detailed information on this in chapter 6.1 Power-System Data.

For additional setting recommendations, verify the following parameter in the power-system data:

- Adjusted rated frequency
- Adjusted rated voltage of the protected object
- Adjusted rated voltage of the voltage transformer of the applicable measuring point

Parameter: Threshold Value

- Default setting (_:13591:3) Threshold = 1.10

The Threshold parameter is used to describe the value for the permissible continuous overexcitation. The default value is a practical value used for transformers. The value may be less for generator applications. These values can be found in the manufacturer's information.

Parameter: Time Delayed Warning

- Default setting (_:13591:101) Warning delay = 10.00 s

When using the Warning delay parameter, the time can be determined by which the warning indication of the stage should be delayed after the pickup. This time delay depends on the specific application. This time must clearly exceed the reaction time of the regulators. 10 seconds is a feasible value.

Parameter: Cooling Time Therm. Replica

- Default setting (_:13591:102) Cooling time therm.replica = 3600 s

The Cooling time therm.replica parameter is used to define the cooling characteristics of the thermal replica. If concrete specifications are not given, the default value can be maintained.

Parameter: V/f /time value pairs (operate curve)

With this parameter, the number of pairing points along the thermal operate curve are defined. This is required for the calculation. The number of points defines the accuracy of the image of the specified characteristic curve. Adjust the value individually.

Set a V/f/time value pair for each characteristic-curve point. The setting depends on the characteristic curve you want to realize. The default settings refer to a Siemens standard transformer.

NOTE
The value pairs must be entered in continuous order.

NOTE
Note that the V/f values that are lower than the V/f values of the smallest characteristic curve point do not extend the operate time. Up to the smallest characteristic-curve point, the characteristic curve runs parallel to the V/f axis. V/f values that are larger than the V/f value of the largest characteristic-curve point do not reduce the operate time. From the largest characteristic-curve point, the pickup characteristic runs parallel to the V/f axis (see Characteristic Curve, Page 931).

6.25.4 Stage with Independent Characteristic Curve (Definite-T)

6.25.4.1 Function Description

Logic

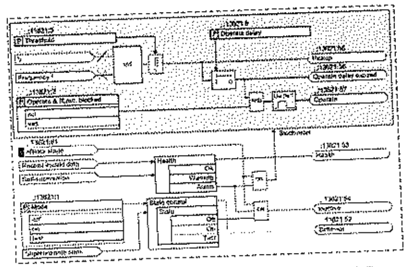

Figure 6-335 Logic of the Overexcitation Protection with Independent Characteristic Curve (Definite-Time Stage)

Method of Measurement

This stage evaluates also the V/f value that is identical to the input value of the thermal stage. Measurement-relevant details can be found in chapter 6.25.3 Stage with Dependent Characteristic Curve (Thermal Stage).

How the Definite-Time Stage Works

The stage consists of a threshold and a time delay stage. If the V/f value is greater than the set threshold value (_:13621:3) Threshold, then the stage is tripped after an adjustable time delay has elapsed. You can set the time delay with the parameter (_:13621:6) Operate delay.

The dropout ratio for the Threshold is fixed to 98 %.

6.25.4.2 Application and Setting Notes

The definite-time stage can be applied when fast tripping is required in the presence of high V/f values. In this case, the stage was superimposed on the thermal, dependent stage.

Parameter: Threshold Value

- Default setting (_:13621:3) Threshold = 1.40

The Threshold parameter is used to describe the overexcitation value that causes the tripping function. The default value matches a feasible upper limit.

Parameter: Tripping delay

- Default setting (_:13621:6) Operate delay = 1.00 s

The Operate delay parameter is used to determine the time by which the stage is delayed after the pickup. This time delay depends on the specific application. The default value is practical for the application described in the previous chapter.

6.25.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:13621:1	Definite-T 1:Mode		• off • on • test	off
_:13621:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13621:3	Definite-T 1:Threshold		1.00 to 1.40	[illegible]
_:13621:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.00 s
Therm. charact.				
_:13591:1	Therm.charact.:Mode		• off • on • test	off
_:13591:2	Therm.charact.:Operate & flt.rec. blocked		• no • yes	no
_:13591:3	Therm.charact.:Threshold		1.00 to 1.20	1.10
_:13591:101	Therm.charact.:Warning delay		0.00 s to 60.00 s	10.00 s
_:13591:102	Therm.charact.:Cooling time therm.replica		0 s to 100 000 s	3600 s

6.25.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:322	General:V/f	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:13621:81	Definite-T 1:>Block stage	SPS	I
_:13621:54	Definite-T 1:Inactive	SPS	O
_:13621:52	Definite-T 1:Behavior	ENS	O
_:13621:53	Definite-T 1:Health	ENS	O
_:13621:55	Definite-T 1:Pickup	ACD	O
_:13621:56	Definite-T 1:Operate delay expired	ACT	O
_:13621:57	Definite-T 1:Operate	ACT	O
Therm. charact.			
_:13591:81	Therm.charact.:>Block stage	SPS	I
_:13591:501	Therm.charact.:>Reset thermal replica	SPS	I
_:13591:54	Therm.charact.:Inactive	SPS	O
_:13591:52	Therm.charact.:Behavior	ENS	O
_:13591:53	Therm.charact.:Health	ENS	O
_:13591:55	Therm.charact.:Pickup	ACD	O
_:13591:301	Therm.charact.:Warning	ACT	O
_:13591:57	Therm.charact.:Operate	ACT	O
_:13591:321	Therm.charact.:V/f th.	MV	O

ВЯРНО С ОРИГИНАЛА

755

6.26 Unbalanced-Load Protection

6.26.1 Overview of Functions

The Unbalanced-load protection function detects unbalanced loads or [illegible] of electrical machines (generators and motors). Unbalanced loads create a counter-rotating magnetic field at double frequency in the rotor. The skin effect leads to local overheating on the surface of the rotor bars in the transition between the slot wedges and the winding bundles. Another effect of unbalanced loads is the overheating of the damper winding.

6.26.2 Structure of the Function

The Unbalanced-load protection function is used in the protection function group. The Unbalanced-load protection function is preconfigured with 1 stage. A maximum of 2 stages can operate simultaneously in the function.

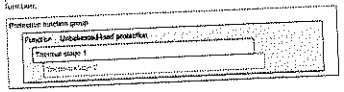

Figure 6-336 Structure/Embedding of the Function

6.26.3 Function Description

Logic of the Stage

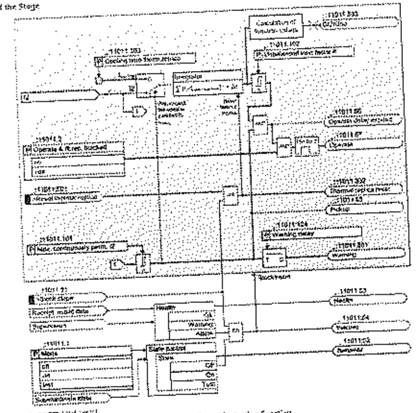

Figure 6-337 Logic Diagram of the Unbalanced-Load Protection Function

Method of Measurement

The stage uses the negative-sequence current I_2 as a measurand. The negative-sequence current is calculated from the measured 3-phase currents according to the defining equation of symmetrical components.

Warning Stage

If the negative-sequence current I_2 continuously exceeds the parameter `Max. continuously perm. I2`, the warning indication is given after expiry of a set time `Warning delay`.

Thermal Characteristic Stage

The machine manufacturers indicate the permissible unbalanced load using the following formula:

With
T_{perm} Permissible time of the negative-sequence current
K Unbalanced-load factor of the machine (parameter `Unbalanced load factor K`)
$I_{2/Irated,machine}$ Actual negative-sequence current as a per unit value (negative-sequence current/rated current of the machine)

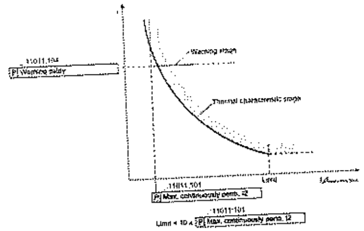

Figure 6-338 Operate Curve of the Unbalanced-Load Protection

The parameter `Unbalanced load factor K` depends on the machine. It also represents the time in seconds during which the machine can be loaded with a 100 % unbalanced load. This factor is typical in a range from 5 s to 40 s. The heating of the protected object starts to calculate as soon as the negative-sequence current I_2 exceeds the parameter `Max. continuously perm. I2`. The operate time is calculated from the flowing negative-sequence current I_2 with an integrating method of measurement depending on the thermal characteristic. As soon as the integrate result reaches the parameter `Unbalanced load factor K`, the thermal characteristic stage operates.

Limitation of Operate Curve

To avoid an overfunction of the thermal characteristic stage in the situation of unbalanced short circuits (for example, 2-phase short circuit), the input current I_2 is restricted to an upper limit. The limiting value is 10 times of `Max. continuously perm. I2`. If I_2 exceeds the limit, the operate time of the function is constant.

In addition, the thermal memory is limited to 200 % of `Unbalanced load factor K`. The limitation avoids a too long cooling after a delayed short-circuit tripping (for example, of external power-system faults).

Cooling Time Thermal Replica

The thermal replica starts to cool down as soon as the negative-sequence current I_2 is lower than `Max. continuously perm. I2`. The thermal replica decreases according to the parameter `Cooling time therm. replica`. The parameter `Cooling time therm. replica` is the time required by the thermal replica to cool down from 100 % to 0 %. If the parameter `Cooling time therm. replica` is set to 0, the thermal replica is reset immediately.

The parameter `Cooling time therm. replica` depends on the construction type of the machine, especially of the damper winding. Preloading is considered when unbalanced loading occurs again during the cooling time. The protection device thus operates in a shorter time.

Functional Measured Values

The following formula is used to calculate the functional measured value Θ/Θop:

$$\Theta/\Theta op = \frac{\sum_{0}^{t}(I_2/I_{rated,machine})^2 \cdot \Delta t}{K} \cdot 100\,\%$$

With

Θ/Θop	Functional measured value indicating the thermal replica of the unbalanced load
$\sum_{0}^{t}(I_2/I_{rated,machine})^2 \cdot \Delta t$	Integrating method of measurement of the thermal replica of the negative-sequence system
K	Unbalanced load factor of the machine (parameter `Unbalanced load factor K`)
$I_{2/Irated,machine}$	Unbalanced load as a per unit value (negative-sequence current/rated current of the machine)

If the functional measured value reaches 100 %, the operate of the function is initiated.

6.26.4 Application and Setting Notes

The function is used in the applications of machines. You can get the necessary settings from the technical data of the synchronous generators and motors. The setting example is applied for a generator application.

Parameter: `Max. continuously perm. I2`, `Warning delay`

- Default setting (_:11011:101) `Max. continuously perm. I2` = 10.0 %
- Default setting (_:11011:104) `Warning delay` = 15 s

If the negative-sequence current I_2 exceeds `Max. continuously perm. I2`, the stage picks up and a warning indication is given after the set time delay `Warning delay`.

The parameter `Max. continuously perm. I2` is given in percentage of the rated current of the protected object.

The setting value of the parameter `Max. continuously perm. I2` depends on following parts:

- Design of the machine (salient pole or nonsalient pole rotor synchronous machine)
- Cooling system (directly or indirectly cooled)
- Size of the machine

Depending on the standards IEEE C50.12 and IEC 60034-1, the parameter is given in the range between 5 % and 12 %. To set the parameter `Max. continuously perm. I2`, technical data of the machine is

required. The technical data of the machine is provided in the Technical Data Sheet of the machine manufacturer.

EXAMPLE

The following example shows the setting of the parameter `Max. continuously perm. I2`. The value 10 % is selected in the example.

To avoid raising the warning indication too fast, Siemens recommends a longer delay. Setting the parameter `Warning delay` in the range of 10 s to 20 s is practicable. 15 s is selected in the example.

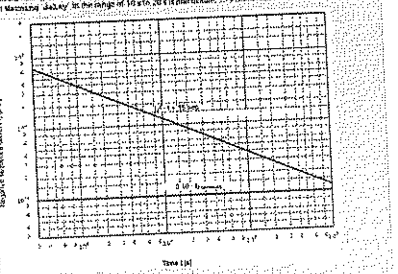

Figure 6-339 Example of an Unbalanced-Load Characteristic Specified by the Machine Manufacturer

Parameter: `Unbalanced load factor K`

- Default setting (_:11011:102) `Unbalanced load factor K` = 15 s

`Unbalanced load factor K` can be derived from the unbalanced load characteristic according to Figure 6-339. You can read the time corresponding to `Unbalanced load factor K` at the point $I_2/I_{rated,machine}$ = 1. In this example, this is the p.u. value 10[1] which corresponds to a time of 15 s. As the example shows, the time is often written directly on the characteristic curve.

Parameter: `Cooling time therm. replica`

- Default setting (_:11011:103) `Cooling time therm. replica` = 1500 s

The parameter `Cooling time therm. replica` establishes the time required by the protected object to cool down the thermal replica to the initial value. If the machine manufacturer does not provide this information, the setting value of `Cooling time therm. replica` can be calculated from the setting values of `Unbalanced load factor K` and `Max. continuously perm. I2` by the formula in the following example.

EXAMPLE

$$\text{Cooling time therm. replica} = \frac{\text{Unbalanced load factor K}}{(\text{Max. continuously perm. I2})^2}$$

Max. continuously perm. I_2 = 10.0 % (corresponds to 0.1)
Unbalanced load factor K = 15 s
Cooling time therm. replica = 1500 s

6.26.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Therm. Stage 1				
_:11011:1	Therm. Stage 1:Mode		• off • on • test	off
_:11011:2	Therm. Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11011:101	Therm. Stage 1:Max. continuously perm. I2		3.0 % to 30.0 %	10.0 %
_:11011:102	Therm. Stage 1:Unbalanced load factor K		1.0 s to 100.0 s	15.0 s
_:11011:103	Therm. Stage 1:Cooling time therm.replica		0 s to 50000 s	1500 s
_:11011:104	Therm. Stage 1:Warning delay		0.0 s to 60.0 s	15.0 s

6.26.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Therm. Stage 1			
_:11011:81	Therm. Stage 1:>Block stage	SPS	I
_:11011:500	Therm. Stage 1:>Reset thermal replica	SPS	I
_:11011:53	Therm. Stage 1:Health	ENS	O
_:11011:54	Therm. Stage 1:Inactive	SPS	O
_:11011:52	Therm. Stage 1:Behavior	ENS	O
_:11011:302	Therm. Stage 1:Thermal replica reset	SPS	O
_:11011:301	Therm. Stage 1:Warning	ACD	O
_:11011:55	Therm. Stage 1:Pickup	ACD	O
_:11011:56	Therm. Stage 1:Operate delay expired	ACT	O
_:11011:57	Therm. Stage 1:Operate	ACT	O
_:11011:303	Therm. Stage 1:Θ/Θop	MV	O

6.27 Instantaneous High-Current Tripping

6.27.1 Overview of Functions

The Instantaneous high-current tripping function has the following tasks:
- Instantaneous tripping when switching onto an existing fault, for example, if a grounding switch is closed
- Instantaneous disconnection of high currents above the highest overcurrent-protection stage.

6.27.2 Structure of the Function

The Instantaneous high-current tripping function offers 2 different increment types:
- Stage with standard release method
- Stage with release method via protection interface (only applicable if the device is equipped with a protection interface)

The functions with the stage for the standard release procedure is factory-set.

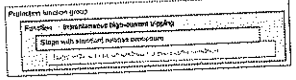

Figure 6-340 Structural Embedding of the Function

6.27.3 Standard Release Procedure

Logic

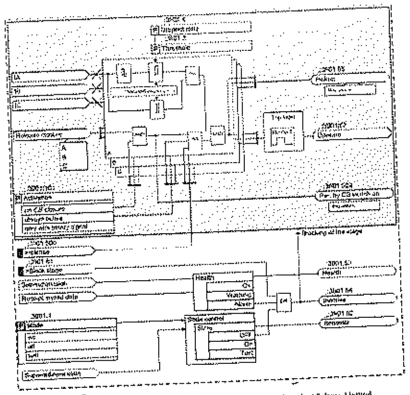

Figure 6-341 Logic Diagram of Instantaneous High-Current Tripping with Standard Release Method

Activation

Using the Activation parameter, you set the conditions under which the stage is released.
- on CB closure

With this procedure, the stage is released only if the circuit breaker is about to be closed (the CB is open) or if the circuit breaker is being closed or if the binary input signal >release is active. The only signals are generated Det. by CB switch as is described in section [illegible] Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions.
- always active

The stage is always released and is thus independent of closing of the circuit breaker switch and of the binary input signal >release.
- only with binary signal

The stage is released only if the binary input signal >release is active.

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.
- Measurement of the fundamental component:
This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
If the current exceeds a preset threshold value by
current > 2·√2 threshold value
this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

6.27.4 Application and Setting Notes

Parameter: Activation
- Default setting (_:3901:101) Activation = on CB closure

Using the parameter Activation, you define the conditions under which the stage is released.

Parameter Value	Description
on CB closure	Select this setting to activate the stage only when the circuit breaker is closed.
always active	Select this setting to release the stage directly.
only with binary signal	Select this setting to release the stage via an external signal.

Parameter: Threshold
- Default setting (_:3901:3) Threshold = 10.0 A for I_{rated} = 1 A or 50.0 A for I_{rated} = 5 A

The stage works independently of the position of the remote circuit breakers. For this reason, set the Threshold so that the fault current flowing through does not trigger the stage. Thus, use this stage only if current grading over the protected object is possible, that is, for transformers, shunt reactors or long lines with low source impedance. In other cases, deactivate the stage.

EXAMPLE
Calculation example for current grading of a 110 kV overhead line measuring 150 mm²
s (length) = 100 km;
R_1/s = 0.21 Ω/km;
X_1/s = 0.43 Ω/km
Since the stage is non-directional, the calculation must consider the maximum short-circuit power at the start of the line or at the opposite end:
S_{sc}'' = 3.5 GVA (subtransient, because the function can respond to the 1st peak value)
Current transformer: 600 A/5 A
The line impedance Z_L and the minimum source impedance Z_S are calculated on this basis:

Line Impedance Z_L and Source Impedance Z_S:
$$Z_1/s = \sqrt{0.21^2 + 0.43^2}\ \Omega/km = 0.479\ \Omega/km$$
$$Z_L = 0.479\ \Omega/km \cdot 100\ km = 47.9\ \Omega$$
$$Z_S = \frac{110\ kV^2}{3500\ MVA} = 3.46\ \Omega$$

The maximum 3-phase short-circuit current I_{sc}'' flowing through is (at a source voltage of 1.1 V_N):

$$I_{sc} = \frac{1.1 \cdot V_{N}}{\sqrt{3} \cdot (Z_S + Z_L)} = \frac{1.1 \cdot 110\ kV}{\sqrt{3} \cdot (3.46\ \Omega + 47.9\ \Omega)} = 1360\ A$$

With a safety margin of 10 %, the following setting value results:
- Threshold value (primary) = 1.1 · 1360 A = 1496 A
- Threshold value (secondary) = $1.1 \cdot \frac{1360\ A}{600\ A} \cdot 5\ A$ = 12.5 A

If short-circuit currents exceed 1496 A (primary) or 12.5 A (secondary), there is a short circuit on the line to be protected. It can be disconnected immediately.

NOTE
The calculation was performed with absolute values, which is accurate enough for overhead lines. A complex calculation is required only if the source impedance and the line impedance have extremely different angles.

Parameter: Dropout ratio
- Recommended setting value (_:3901:4) Dropout ratio = 0.90

The recommended setting value of 0.90 is sufficient for many applications. To obtain high precision measurements, the Dropout ratio can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the parameter Dropout ratio. This avoids chattering of the tripping stage.

6.27.5 Release Procedure via Protection Interface

This stage can be applied only if the device is equipped with a protection interface.

Logic

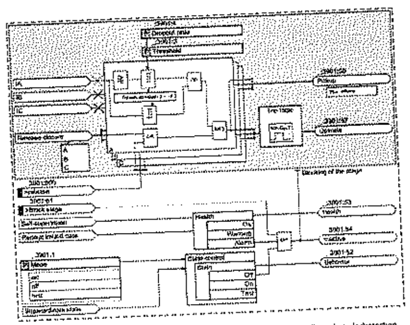

Figure 6-342 Logic Diagram of Instantaneous High-Current Tripping with Release Procedure via Protection Interface

Release

If one of the following conditions is fulfilled, the stage is released (the internal Release signal is present) (for further information, see chapter [illegible]):
- No voltage has yet been applied to the protected object, which means that the remote circuit breakers are open, or
- Switching to the local circuit breaker is imminent.

These conditions are recognized internally if a circuit breaker is open or just closed.
Furthermore, the stage can be activated externally via the >release binary input signal.

NOTE
To enable internal release of the stage, the devices at all ends of the protected object must be informed of the circuit-breaker position (the circuit-breaker auxiliary contacts must be connected to the devices; the respective binary input signals must be configured).

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.

- Measurement of the fundamental component:
This method of measurement processes the sampled current values and filters out the fundamental component numerically. A DC component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
If the current exceeds a preset threshold value by
current > 2·√2 threshold value
this stage will use unfiltered measurands in addition. Thus, very short operate times are possible.

6.27.6 Application and Setting Notes

Parameter: Threshold
- Default setting (_:3901:3) Threshold = 2.5 A for I_{rated} = 1 A or 12.5 A for I_{rated} = 5 A

Select the value high enough for the protection not to pick up on the RMS value of the inrush current that occurs when the local circuit breaker is closed. You do not have to consider short-circuit currents flowing through, because the stage is released only if the circuit breakers are opened at all remote ends of the protected object or the release was caused by the binary input >release.

Parameter: Dropout ratio
- Recommended setting value (_:3901:4) Dropout ratio = 0.90

The recommended setting value of 0.90 is sufficient for many applications. To obtain extremely accurate measurements, the dropout ratio can be reduced. If you expect highly fluctuating measurands at the pickup threshold, you can increase the dropout ratio. This avoids chattering of the tripping stage.

6.27.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Standard 1				
_:3901:1	Standard 1:Mode		• off • on • test	off
_:3901:101	Standard 1:Activation		• on CB closure • only with binary signal • always active	on CB closure
_:3901:3	Standard 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:3901:4	Standard 1:Dropout ratio		0.50 to 0.95	0.90

6.27.8 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O

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No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
Standard 1			
_:3901:500	Standard 1:>Release	SPS	I
_:3901:81	Standard 1:>Block stage	SPS	I
_:3901:54	Standard 1:Inactive	SPS	O
_:3901:52	Standard 1:Behavior	ENS	O
_:3901:53	Standard 1:Health	ENS	O
_:3901:300	Standard 1:Pickup V0	ACT	O
_:3901:56	Standard 1:Op. delay exp.	ACT	O
_:3901:57	Standard 1:Operate	ACT	O

6.28 Overvoltage Protection with 3-Phase Voltage

6.28.1 Overview of Functions

The function **Overvoltage protection with 3-phase voltage** (ANSI 59) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components, machines, etc.) against damages caused by overvoltage
- Decouple systems (for example, wind power supply)

Abnormally high voltages in power systems are caused by voltage controller failure at the transformer or on long transmission lines under low-load conditions.

When using common-mode reactors in the protected power system, the device must shut down the line quickly if the reactors fail (for example, due to fault clearance). The insulation is endangered by the overvoltage condition.

Overvoltages at capacitor banks can be caused by resonances with line or transformer inductances.

In power plants increased voltage levels can be due to one of these factors:

- Incorrect operation when controlling the excitation system manually
- Failure of the automatic voltage controller
- After full load shedding of a generator
- Generators which are disconnected from the network or in island mode

6.28.2 Structure of the Function

The **Overvoltage protection with 3-phase voltage** function is used in protection function groups with voltage measurement.

The **Overvoltage protection with 3-phase voltage** function is preconfigured by the manufacturer with 2 **Definite time-overvoltage protection** stages. In this function, the following stages can operate simultaneously:

- 3 stages **Definite time-overvoltage protection**
- 2 stages **Inverse time overvoltage protection**

Stages that are not preconfigured are shown in gray in the following figure.

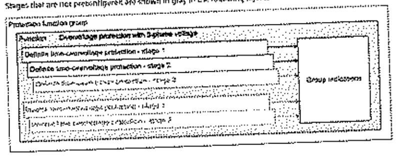

Figure 6-343 Structure/Embedding of the Function

6.28.3 Stage with Definite-Time Characteristic Curve

6.28.3.1 Description

Logic of the Stage

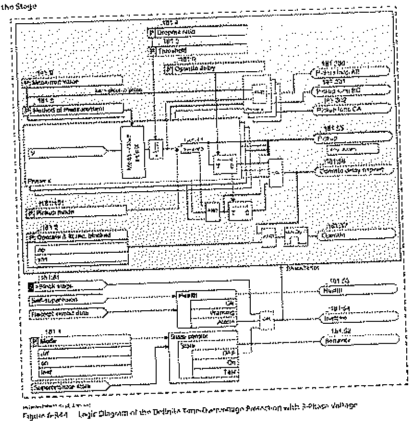

Figure 6-344 Logic Diagram of the Definite Time-Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the RMS value.

- Measurement fundamental comp.:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

The Pickup mode parameter defines whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (3 out of 3) or if only 1 measuring element detects the overvoltage condition (1 out of 3).

Measured Value

Use the Measured value parameter to define whether the tripping stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal >Block stage.

6.28.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:181:8) Method of measurement = fundamental comp.

With the Method of measurement parameter, you define whether the stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the threshold value of the stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting (_:181:9) Measured value = phase-to-phase

With the Measured value parameter, you define whether the stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep phase-to-phase as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the measured value phase-to-phase as the default setting.
phase-to-ground	Select the phase-to-ground setting if you want to detect voltage imbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting (_:181:3) Threshold = 110 V

Depending on the Measured value, the Threshold is set either as phase-to-phase quantity or as phase-to-ground quantity. The default setting assumes that the voltage range is monitored on long-distance transmission lines under low-load conditions.

Specify the Threshold (pickup threshold) for the specific application.

Parameter: Operate delay

- Default setting (_:181:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:181:4) Dropout ratio = 0.95

The recommended set value of 0.95 is appropriate for most applications. To achieve high measurement precision, the Dropout ratio can be reduced, to 0.98, for example.

Parameter: Pickup mode

- Recommended setting value (_:181:101) Pickup mode = 1 out of 3

With the Pickup mode parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (3 out of 3) or if only 1 measuring element detects the overvoltage condition (1 out of 3).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends 1 out of 3 as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

EXAMPLE

Example for 2-stage overvoltage protection

The example describes the possible settings for a 2-stage overvoltage protection function. You will look at the settings of the parameters Threshold and Operate delay.

- 1 Stage:
  To detect stationary overvoltages, set the threshold value of the first overvoltage-protection element at least 10 % above the max. stationary phase-to-phase voltage anticipated during normal operation. Since the setting parameter Measured value is phase-to-phase voltage and a secondary rated voltage of 100 V, the secondary setting value of the first overvoltage-protection element is calculated as follows:

  Threshold value: 10 % above V_{rated}

  $V_{threshold,sec} = 1.1 \cdot V_{rated,sec} = 1.1 \cdot 100\,V = 110\,V$

  This requires that the primary rated voltages of protected object and voltage transformer are identical. If they are different, you have to adapt the pickup value.

  For the Operate delay, set a value of 3 s.

- 2 Stage:
  The second overvoltage-protection stage is intended for high overvoltages with short duration. A high pickup value is selected here, for example, 1.5 times the rated voltage. A time delay setting of 0.1 s to 0.2 s is sufficient then.

Stage	Setting Values	
	Threshold value	Time delay
1	Time delay 1.1 V_{rated}	3 s
2	1.5 V_{rated}	0.1 s to 0.2 s

6.28.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:181:1	Definite-T 1:Mode		• off • on • test	off
_:181:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:181:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:181:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:181:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:181:3	Definite-T 1:Threshold		0.300 V to 340.000 V	110.000 V
_:181:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:181:6	Definite-T 1:Operate delay		0.00 s to 300.00 s	3.00 s
Definite-T 2				
_:182:1	Definite-T 2:Mode		• off • on • test	off
_:182:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:182:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:182:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:182:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:182:3	Definite-T 2:Threshold		0.300 V to 340.000 V	130.000 V
_:182:4	Definite-T 2:Dropout ratio		0.90 to 0.99	0.95
_:182:6	Definite-T 2:Operate delay		0.00 s to 300.00 s	0.50 s

6.28.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:181:81	Definite-T 1:>Block stage	SPS	I
_:181:54	Definite-T 1:Inactive	SPS	O
_:181:52	Definite-T 1:Behavior	ENS	O

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No.	Information	Data Class (Type)	Type
_:181:53	Definite-T 1:Health	ENS	O
_:181:55	Definite-T 1:Pickup	ACD	O
_:181:300	Definite-T 1:Pickup loop AB	SPS	O
_:181:301	Definite-T 1:Pickup loop BC	SPS	O
_:181:302	Definite-T 1:Pickup loop CA	SPS	O
_:181:56	Definite-T 1:Operate delay expired	ACT	O
_:181:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:182:81	Definite-T 2:>Block stage	SPS	I
_:182:54	Definite-T 2:Inactive	SPS	O
_:182:52	Definite-T 2:Behavior	ENS	O
_:182:53	Definite-T 2:Health	ENS	O
_:182:55	Definite-T 2:Pickup	ACD	O
_:182:300	Definite-T 2:Pickup loop AB	SPS	O
_:182:301	Definite-T 2:Pickup loop BC	SPS	O
_:182:302	Definite-T 2:Pickup loop CA	SPS	O
_:182:56	Definite-T 2:Operate delay expired	ACT	O
_:182:57	Definite-T 2:Operate	ACT	O

6.28.4 Stage with Inverse-Time Characteristic Curve

6.28.4.1 Description

Logic of the Stage

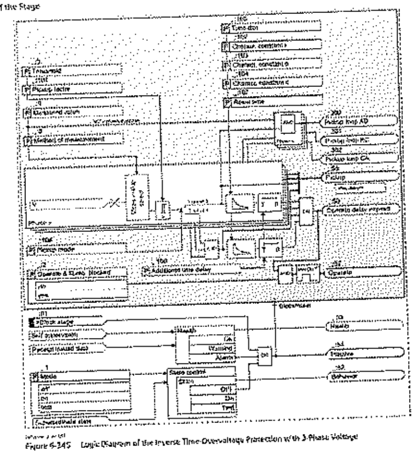

Figure 6-345 Logic Diagram of the Inverse-Time Overvoltage Protection with 3-Phase Voltage

Method of Measurement

Use the Method of measurement parameter to define whether the stage uses the Fundamental comp. or the RMS value.

- Measurement Fundamental comp.:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

- Measurement RMS value
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Pickup Mode

With the Pickup mode parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (3 out of 3) or if only 1 measuring element detects the overvoltage condition (1 out of 3).

Measured Value

Use the Measured value parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup and Operate Curve

When the input voltage exceeds the threshold value by a settable value Pickup factor, the stage picks up and the inverse-time characteristic curve is processed. Operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

$$T_{op} = T_{inv} + T_{Add}$$

Where

T_{op}	Operate delay
T_{inv}	Inverse-time delay
T_{Add}	Additional time delay (parameter Additional time delay)

After pickup, the time value T_{inv} is calculated for every input voltage that exceeds the threshold. An integrator accumulates the value $1/T_{inv}$. Once the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The additional time delay T_{Add} starts. The stage operates after the additional time delay expires.

The inverse-time characteristic is shown in the following Figure.

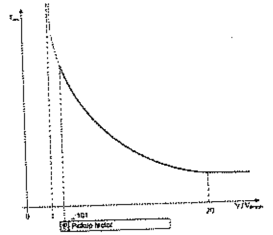

Figure 6-346 Operate Curve of Inverse-Time Characteristic

The inverse-time delay is calculated with the following formula:

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

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (parameter Time dial)
V	Measured voltage
V_{thresh}	Threshold value (parameter Threshold)
k	Curve constant k (parameter Charact. constant k)
α	Curve constant α (parameter Charact. constant α)
c	Curve constant c (parameter Charact. constant c)

When V/V_{thresh} is equal to or greater than 20, the inverse-time delay does not decrease any further.

Dropout Behavior

When the voltage falls below the dropout threshold (0.95 · pickup factor · threshold value), the pickup signal is gone and the dropout is started. You can define the dropout behavior via parameter Reset time. Instantaneous reset takes place by setting Reset time to 0 s. A delayed reset takes place by setting the desired delay time.

During the Reset time (> 0 s), the elapsed operate delay is frozen. If the pickup value is exceeded again within this period, the stage operates when the rest of operate delay expires.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal >Block stage.

6.28.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:8) Method of measurement = Fundamental comp.

With the Method of measurement parameter, you define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
Fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the threshold value of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting (_:9) Measured value = phase-to-phase

With the Measured value parameter, you define whether the tripping stage monitors the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.

Parameter Value	Description
phase-to-phase	If you want to monitor the voltage range, keep phase-to-phase as the default setting. In this case, the function will not pick up on ground faults. Siemens recommends the Measured value phase-to-phase as the default setting.
phase-to-ground	Select the phase-to-ground setting if you want to detect voltage unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold, Pickup factor

- Default setting (_:3) Threshold = 110.000 V
- Default setting (_:102) Pickup factor = 1.10

The stage picks up when the measured voltage value exceeds the pickup value Threshold · Pickup factor.

Depending on the Measured value, the Threshold is set either as phase-to-phase quantity or as phase-to-ground quantity.

With the Pickup factor parameter, you modify the pickup value. To avoid a long time operate delay after pickup when the measured value is slightly over the threshold, Siemens recommends using the default setting.

Specify the Threshold (pickup threshold) and Pickup factor for the specific application.

Parameter: Pickup mode

- Recommended setting value (_:101) Pickup mode = 1 out of 3

With the Pickup mode parameter, you define whether the protection stage picks up if all 3 measuring elements detect the overvoltage condition (3 out of 3) or if only 1 measuring element detects the overvoltage condition (1 out of 3).

Parameter Value	Description
1 out of 3	Select the setting for protection applications or for monitoring the voltage range. Siemens recommends 1 out of 3 as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting (_:103) Charact. constant k = 1.00
- Default setting (_:104) Charact. constant α = 1.000
- Default setting (_:104) Charact. constant c = 0.000

With the parameters Charact. constant k, Charact. constant α, and Charact. constant c, you define the required inverse-time characteristic curve.

Parameter: Time dial

- Default setting (_:105) Time dial = 1.00

With the Time dial parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve, Siemens recommends leaving the Time dial parameter at 1.00 (default setting).

Parameter: Additional time delay

- Default setting (_:106) Additional time delay = 0.00 s

With the Additional time delay parameter, you define a definite time delay in addition to the inverse time delay.

If the setting is left on its default value of 0 s, only the inverse-time delay is operative.

Parameter: Reset time

- Default setting (_:107) Reset time = 0.00 s

With the Reset time parameter, you define the reset time delay which is started when the voltage falls below the dropout threshold. Set the parameter Reset time to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the Reset time to an appropriate value (> 0 s) to ensure the operation. Otherwise Siemens recommends to keep the default value to ensure a fast reset of the function.

6.28.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:9	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:101	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3

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Addr.	Parameter	C	Setting Options	Default Setting
_:3	Inverse-T #:Threshold		0.300 V to 340.000 V	110.000 V
_:101	Inverse-T #:Pickup factor		1.00 to 1.20	1.10
_:101	Inverse-T #:Charac. constant k		0.00 to 300.00	1.00
_:102	Inverse-T #:Charac. constant α		0.010 to 5.000	1.000
_:104	Inverse-T #:Charac. constant c		0.000 to 5.000	0.000
_:105	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:106	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:107	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.28.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.29 Overvoltage Protection with Positive-Sequence Voltage

6.29.1 Overview of Functions

The function Overvoltage protection with positive-sequence voltage (ANSI 59) is used to:

- Detect symmetric stationary overvoltages
- Supervise the voltage range if the positive-sequence voltage is the decisive quantity

Unbalanced overvoltages, for example, caused by ground faults and unbalanced faults, are not detected due to the evaluation of the positive-sequence voltage.

6.29.2 Structure of the Function

The Overvoltage protection with positive-sequence voltage function is used in protection function groups, which are based on voltage measurement.

The function Overvoltage protection with positive-sequence voltage comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

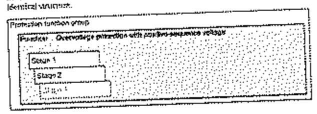

Figure 6-347 Structure/Embedding of the Function

6.29.3 Stage Description

Logic of a Stage

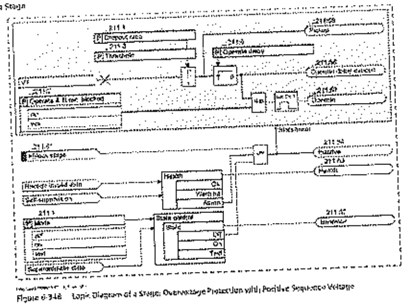

Figure 6-348 Logic Diagram of a Stage: Overvoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal >Block stage.

6.29.4 Application and Setting Notes

Parameter: Threshold

- Default setting (_:211:3) Threshold = 65 V

The Threshold is set according to the definition of the positive sequence system.
Specify the Threshold (pickup threshold) for the specific application.

Parameter: Operate delay

- Default (_:211:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:211:4) Dropout ratio = 0.95

The default value of 0.95 is appropriate for most applications. To achieve high measurement precision, the Dropout ratio can be reduced, to 0.98, for example.

General Notes

If the overvoltage is high, the first stage can trip with a short time delay. If overvoltages are lower, the second stage can either only signal the threshold value violation (see Operation as monitoring function) or trip with a longer delay to allow the voltage controller to regulate the voltage back into the nominal range.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

6.29.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:211:1	Stage 1:Mode		• off • on • test	off
_:211:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:211:3	Stage 1:Threshold		0.300 V to 200.000 V	65.000 V
_:211:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:211:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:212:1	Stage 2:Mode		• off • on • test	off
_:212:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:212:3	Stage 2:Threshold		0.300 V to 200.000 V	75.000 V
_:212:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:212:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.29.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:211:81	Stage 1:>Block stage	SPS	I
_:211:54	Stage 1:Inactive	SPS	O
_:211:52	Stage 1:Behavior	ENS	O
_:211:53	Stage 1:Health	ENS	O
_:211:55	Stage 1:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:211:56	Stage 1:Operate delay expired	ACT	O
_:211:57	Stage 1:Operate	ACT	O
Stage 2			
_:212:81	Stage 2:>Block stage	SPS	I
_:212:54	Stage 2:Inactive	SPS	O
_:212:52	Stage 2:Behavior	ENS	O
_:212:53	Stage 2:Health	ENS	O
_:212:55	Stage 2:Pickup	ACD	O
_:212:56	Stage 2:Operate delay expired	ACT	O
_:212:57	Stage 2:Operate	ACT	O

6.30 Overvoltage Protection with Negative-Sequence Voltage

6.30.1 Overview of Functions

The function Overvoltage protection with negative-sequence voltage (ANSI 47) is used to:

- Monitor the power system and electric machines for voltage unbalances
- Establish a release criterion of overcurrent protection for unbalanced faults

Voltage unbalances can be caused by various factors:

- The most common cause is unbalanced load, caused by different consumers in the individual phases, for example.
- Voltage unbalance can also be caused by phase failure, for example due to a tripped 1-phase fuse, a broken conductor, etc.
- Other causes can include faults in the primary system, for example, at the transformer or in installations for reactive-power compensation.

6.30.2 Structure of the Function

The Overvoltage protection with negative-sequence voltage function is used in protection function groups, which are based on voltage measurement.

The Overvoltage protection with negative-sequence voltage function comes with 2 factory-set stages.

A maximum of 3 stages can be operated simultaneously in the function.

The stages have an identical structure.

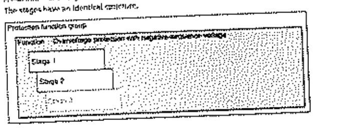

Figure 6-349 Structure/Embedding of the Function

6.30.3 General Functionality

6.30.3.1 Description

Logic

The following figure represents the logic of the average-value calculation of the negative-sequence voltage. The average value is forwarded to all subordinate stages.

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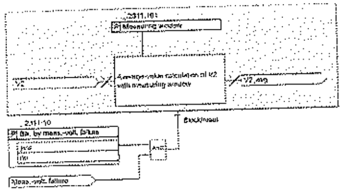

Figure 6-350 Logic Diagram of the General Functionality

Measurand

The average value of negative-sequence voltage is determined by a settable time interval (parameter: Measuring window). With the parameter Measuring window, you can adapt this function to all power-system conditions.

You can set the parameter Measuring window with a large value to get a more accurate calculated result, which leads to a longer pickup time however.

Blocking the Function with Measuring-Voltage Failure Detection

In case of blocking, the picked up function is reset. The following blocking options is available for the function:

- From inside on pickup of the Measuring-voltage failure detection function (see section 8.3.2.1 Overview of Functions).
- From an external source via the binary input signal >Open of the function block Volt.-transf. c. b., which links in the tripping of the voltage-transformer circuit breaker.

The parameter Blk. by meas.-volt. failure can be set so that the measuring-voltage failure detection blocks the function or does not block it.

6.30.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting (_:2311:101) Measuring window = 1 cycle

  With the parameter Measuring window, you can optimize the measuring accuracy or the pickup time of this function.

  For sensitive settings of the parameter Threshold, for example, lower than 10 % of the rated voltage, Siemens recommends using a higher number of cycles. Siemens recommends 10 cycles, and in this case, the pickup time is increased.

  For further information, refer to chapter 11.31 Overvoltage Protection with Negative-Sequence Voltage.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:2311:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the function when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on.
- The binary input signal >Open of the function block VTCB is connected to the voltage-transformer circuit breaker (see chapter 8.3.4.2 Overview of Functions).

Parameter Value	Description
yes	The protection function is blocked (= default setting). Siemens recommends using the default setting.
no	The protection function is not blocked.

6.30.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:10	General:Blk. by meas.-volt. failure		• no • yes	yes
_:2311:101	General:Measuring window		1 cycles to 10 cycles	1 cycles

6.30.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:V2 average	MV	O

6.30.4 Stage with Negative-Sequence Voltage

6.30.4.1 Description

Logic of a Stage

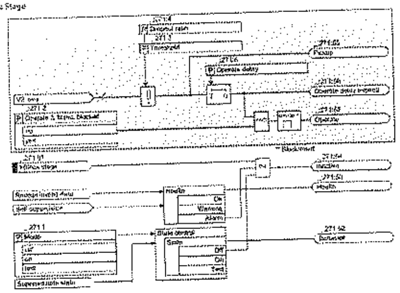

Figure 6-351 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage

Method of Measurement

The stage uses the average value of the negative-sequence voltage, which is calculated from the function block General Functionality. For more information, refer to chapter 6.30.3.1 Description.

Blocking the Stage

In case of blocking, the picked up function is reset. The following blocking option is available for the function:

- From an external or internal source via the binary input signal >Block stage

6.30.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting (_:271:3) Threshold = 5.800 V

The parameter Threshold is set according to the definition of the negative-sequence system.

Specify the Threshold (pickup threshold) for the specific application.

The secondary voltage of the voltage transformer can be used if the voltage transformer is adapted to the rated voltage. The value of the 10 % negative-sequence voltage at a 100 V rated secondary voltage is:

100 V / 1.73 * 0.1 = 5.77 V

Parameter: Dropout ratio

- Default setting (_:271:4) Dropout ratio = 0.95

The default setting of 0.95 is appropriate for most applications.

You can decrease the dropout ratio to avoid chattering of the stage if the threshold value is low. For example, for the stage with a 2 % setting, you can use a dropout ratio of 0.90.

Parameter: Operate delay

- Default setting (_:271:6) Operate delay = 3.00 s

Specify the Operate delay for the specific application. 3.00 s is a practicable value.

For a higher threshold value, a shorter tripping delay is required.

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

Example 1:

Releasing an overcurrent protection stage for unbalanced faults

The following section describes how to set the function to release an Overcurrent-protection stage when unbalanced faults occur. Set the Overcurrent-protection stage only slightly higher than the load current. That is very sensitive. To prevent the Overcurrent-protection stage from picking up inadvertently, the Overcurrent-protection stage is released when the Negative-sequence voltage stage picks up. The Overcurrent-protection stage remains blocked as long as the Negative-sequence voltage stage has not picked up.

Figure 6-352 shows the voltage phasors during a 2-phase local fault between phases B and C. The phase-to-phase voltage V_{BC} is virtually 0.

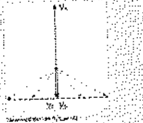

Figure 6-352 Voltage Phasors during a 2-Phase Local Fault

A 2-phase local fault generates a relatively large negative-sequence voltage of up to 50 % referred to the phase-to-ground voltage. The portion of the negative-sequence decreases in case of a remote fault. The lower setting limit results from the possible unbalance at full load. If you assume for example 5 % negative-sequence voltage, the pickup value must be higher. A setting value of 10 % warrants sufficient stability during unbalanced operating states and sufficient sensitivity to release the Overcurrent-protection stage when a fault occurs.

For a secondary rated voltage of 100 V, set the following secondary threshold value:

$$V2_{sec} = \frac{V_{rated,sec} \; 100\ V}{\sqrt{3}} \times 10\,\% = \frac{100\ V}{\sqrt{3}} \times 0.1 = 5.8\ V$$

You can keep the default setting of 0.95 for the dropout ratio. This avoids chattering of the stage.

Set the Negative-sequence voltage stage so that it does not generate a fault record when it picks up and does not initiate tripping. The Overcurrent-protection stage generates a fault indication. The pickup of the Negative-sequence voltage stage is used as the release criterion because the Short-circuit function must be released immediately when the Negative-sequence voltage stage has picked up. The time delay is thus not relevant and can be left at the default setting.

You implement the release of the Overcurrent-protection stage using a logic block chart. An inverter links the pickup of the Negative-sequence voltage stage with the Overcurrent-protection stage blocking.

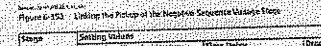

Figure 6-353 Linking the Pickup of the Negative-Sequence Voltage Stage

Stage	Setting Values		
	Secondary Threshold Value	Time Delay	Dropout Ratio
1	5.800 V	3.00 s	0.95

The second stage is not needed. It is deleted or remains off.

Example 2:

A negative-sequence voltage in the auxiliary system of the power plant causes negative-sequence currents on motors. This leads to a thermal overload of the rotors. The following estimation can be used as a basis: 1 % negative-sequence voltage can lead to approximately 5 % or 6 % negative-sequence current.

A negative-sequence voltage can be caused by a broken conductor on the high-voltage side. If a negative-sequence voltage occurs, this can, for example, initiate a switching of the motors in order to prevent a possible trip of an unbalanced-load protection of the motors.

Siemens recommends using multiple stages for a better grading, whereby a sensitive setting of the threshold permits an increased tripping delay.

For a reference, only 2 stages are discussed.

The first stage has a pickup threshold of 10 % with a time delay of 1.5 s. The second stage has a pickup threshold of 3 % with a time delay of 8 s; see Table 6-17. Further, it is assumed that the voltage transformer is well adapted to the rated voltage.

$$V2_{sec} = \frac{100\ V}{1.73} \times \frac{V2\,[\%]}{100\,\%}$$

Table 6-17 Recommended Settings

Stage	Threshold	Operate Delay
Stage 1	5.800 V	1.50 s
Stage 2	1.730 V	8.00 s

6.30.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:271:1	Stage 1:Mode		• off • on • test	off
_:271:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:271:3	Stage 1:Threshold		0.300 V to 200.000 V	5.800 V

Addr.	Parameter	C	Setting Options	Default Setting
_:271:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:271:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:272:1	Stage 2:Mode		• off • on • test	off
_:272:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:272:3	Stage 2:Threshold		0.300 V to 200.000 V	9.000 V
_:272:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:272:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.30.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:271:81	Stage 1:>Block stage	SPS	I
_:271:54	Stage 1:Inactive	SPS	O
_:271:52	Stage 1:Behavior	ENS	O
_:271:53	Stage 1:Health	ENS	O
_:271:55	Stage 1:Pickup	ACD	O
_:271:56	Stage 1:Operate delay expired	ACT	O
_:271:57	Stage 1:Operate	ACT	O
Stage 2			
_:272:81	Stage 2:>Block stage	SPS	I
_:272:54	Stage 2:Inactive	SPS	O
_:272:52	Stage 2:Behavior	ENS	O
_:272:53	Stage 2:Health	ENS	O
_:272:55	Stage 2:Pickup	ACD	O
_:272:56	Stage 2:Operate delay expired	ACT	O
_:272:57	Stage 2:Operate		

6.31 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

6.31.1 Overview of Functions

The function Overvoltage protection with negative-sequence voltage/positive-sequence voltage is used to:

- Monitor the power system and electric machines for voltage unbalances
- Establish a release criterion of overcurrent protection for unbalanced faults

Voltage unbalances can be caused by various factors:

- The most common cause is unbalanced load, caused by different consumers in the individual phases, for example.
- Voltage unbalance can also be caused by phase failures, for example due to a tripped 1-phase fuse, a broken conductor, etc.
- Other causes can include faults in the primary system, for example, at the transformer or in installations for reactive-power compensation.

6.31.2 Structure of the Function

The **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** function is used in protection function groups which are based on voltage measurement.

The **Overvoltage protection with negative-sequence voltage/positive-sequence voltage** function comes with 2 factory-set stages. A maximum of 3 stages can be operated simultaneously in the function. The stages have an identical structure.

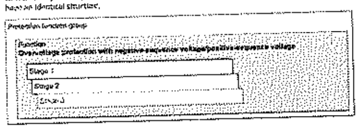

Figure 6-354 Structure/Embedding of the Function

6.31.3 General Functionality

6.31.3.1 Description

Logic

The following figure represents the logic of the average-value calculation of the ratio of negative-sequence voltage to positive-sequence voltage. The average value is forwarded to all subordinate stages.

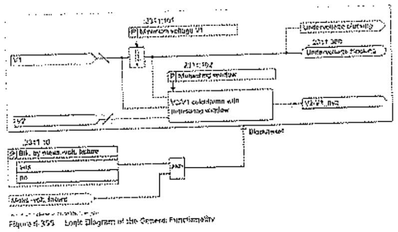

Figure 6-355 Logic Diagram of the General Functionality

Measured

The average value of the ratio of negative-sequence voltage to positive-sequence voltage is determined by a settable time interval (parameter `Measuring window`). With the parameter `Measuring window`, you can adapt this function to all power-system conditions.

You can set the parameter `Measuring window` with a large value to get a more accurate calculation result, which leads to a longer pickup time however.

Blocking the Function with Measuring-Voltage Failure Detection

In case of blocking, the picked up function is reset. The following blocking options is available for the function:

- From inside on pick up of the **Measuring-voltage failure detection** function (see section 8.3.2.1 Overview of Functions).
- From an external source via the binary input signal >Open of the function block **Volt.-transf. c. b.**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter `Blk. by meas.-volt. failure` can be set so that the measuring-voltage failure detection blocks the function or does not block it.

6.31.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting (_:2311:102) `Measuring window = 1 cycle`

With the parameter `Measuring window`, you can optimize the measuring accuracy or the pickup time of this function.

For sensitive settings of the parameter `Threshold`, for example, lower than 10 % of the rated voltage, Siemens recommends using a higher number of cycles. Siemens recommends `10 cycles`, and in this case, the pickup time is increased.

For further information, refer to chapter 11.37 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage.

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:2311:10) `Blk. by meas.-volt. failure = yes`

You use the `Blk. by meas.-volt. failure` parameter to control the behavior of the function when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on.
- The binary input signal >Open of the function block VTCB is connected to the voltage-transformer circuit breaker (see chapter 8.3.2.1 Overview of Functions).

Parameter Value	Description
yes	The protection function is blocked (= default setting). Siemens recommends using the default setting.
no	The protection function is not blocked.

6.31.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:10	General:Blk. by meas.-volt. failure		• no • yes	yes
_:2311:102	General:Measuring window		1 cycles to 10 cycles	1 cycles
_:2311:101	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V

6.31.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:V2/V1	MV	O

6.31.4 Stage with Negative-Sequence Voltage/Positive-Sequence Voltage

6.31.4.1 Description

Logic of a Stage

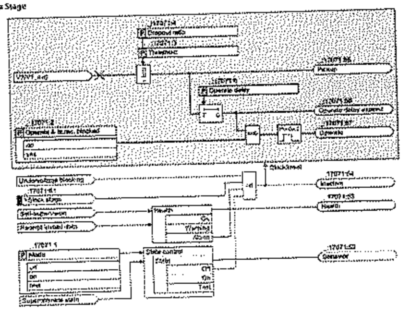

Figure 6-356 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Method of Measurement

The stage uses the average value of the negative-sequence voltage/positive-sequence voltage, which is calculated from the function block General Functionality. For more information, refer to chapter 6.31.3.1 Description.

Blocking the Stage

In case of blocking, the picked up function is reset. The following blocking option is available for the function:

- From an external or internal source via the binary input signal >Block stage

6.31.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting (_:17071:3) `Threshold = 10.00 %`

The parameter `Threshold` is set in percentage according to the definition of the symmetrical components. It is the ratio of the negative-sequence voltage to positive-sequence voltage.

Specify the `Threshold` (pickup threshold) for the specific application.

In the application with a lower threshold setting of about 2.00 %, there is a risk of an overfunction due to the measuring errors with small values as well as an influence via disturbances.

Parameter: Dropout ratio

- Default setting (_:17071:4) `Dropout ratio = 0.95`

The default setting of `0.95` is appropriate for most applications if a higher threshold is used.

You can decrease the dropout ratio to avoid chattering of the stage if the threshold value is low. For example, for the stage with a 2 % setting, you can use a dropout ratio of 0.90

Parameter: Operate delay

- Default setting (_:17071:6) `Operate delay = 3.00 s`

Specify the `Operate delay` for the specific application. When using the sensitive setting of the threshold value that is described in this chapter, the function can be delayed by 3.00 s.

For a higher threshold value, a shorter tripping delay is required.

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the `Operate & flt.rec. blocked` parameter.

Example 1:

Releasing an overcurrent protection stage for unbalanced faults

The following section describes how to set the function to release an Overcurrent-protection stage when unbalanced faults occur. Set the Overcurrent-protection stage only slightly higher than the load current, that is very sensitive. To prevent the Overcurrent-protection stage from picking up inadvertently, the Overcurrent-protection stage is released when the Negative-sequence voltage stage picks up. The Overcurrent-protection stage remains blocked as long as the Negative-sequence voltage stage has not picked up.

Figure 6-357 shows the voltage phasors during a 3-phase load fault between phases B and C. The phase-to-phase voltage V_{BC} is virtually 0.

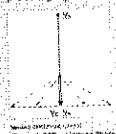

Figure 6-357 Voltage Phasors during a 2-Phase Local Fault

A 2-phase local fault generates a relatively large negative-sequence voltage of up to 100 % referred to the positive-sequence voltage. The portion of the negative-sequence decreases in case of a remote fault. The lower setting limit results from the possible unbalance at full load. If you assume for example 5 % of the negative-sequence voltage to positive-sequence voltage, the pickup value must be higher. A setting value of 10 % warrants sufficient stability during unbalanced operating states and sufficient sensitivity to release the Overcurrent-protection stage when a fault occurs.

You can keep the default setting of 0.95 for the dropout ratio. This avoids chattering of the stage.

Set the Negative-sequence voltage stage so that it does not generate a fault when it picks up and does not initiate tripping. The Overcurrent-protection stage generates a fault indication. The pickup of the Negative-sequence voltage stage is used as the release criterion because the Short-circuit function must be released

immediately when the Negative-sequence voltage stage has picked up. The time delay is thus not relevant and can be left at the default setting.

You implement the release of the Overcurrent-protection stage using a logic block chart. An inverter links the pickup of the Negative-sequence voltage stage with the Overcurrent-protection stage blocking.

Figure 6-358 Linking the Pickup of the Negative-Sequence Voltage Stage

Stage	Setting Values		
	Percentage of the Negative-Sequence Voltage to Positive-Sequence Voltage	Time Delay	Dropout Ratio
1	10.00 %	3.00 s	0.95

The second stage is not needed. It is deleted or remains off.

Example 2:

A negative-sequence voltage in the auxiliary system of the power plant causes negative-sequence currents in motors. This leads to a thermal overload of the motors. The following estimation can be used as a basis: 1 % negative-sequence voltage can lead to approximately 5 % or 6 % negative-sequence current.

A negative-sequence voltage can be caused by a broken conductor on the high-voltage side. If a negative-sequence voltage occurs, you can, for example, initiate a switching of the infeed in order to prevent a protection trip of an unbalanced-load protection of the motors.

Siemens recommends using multiple stages for a better grading, whereby a sensitive setting of the threshold permits an increased tripping delay.

For a reference, only 2 stages are described.

The first stage has a picking threshold of 10 % with a time delay of 1.5 s. The second stage has a pickup threshold of 3 % with a time delay of 8 s, see Table 6-18.

Table 6-18 Recommended Settings

Stage	Threshold	Operate Delay
Stage 1	10.00 %	1.50 s
Stage 2	3.00 %	8.00 s

6.31.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:17071:1	Stage 1:Mode		• off • on • test	off
_:17071:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:17071:3	Stage 1:Threshold		0.50 % to 100.00 %	10.00 %
_:17071:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:17071:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:17072:1	Stage 2:Mode		• off • on • test	off

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Addr.	Parameter	C	Setting Options	Default Setting
_:17072:2	Stage 2 Operate & flt.rec. blocked		• no • yes	no
_:17072:3	Stage 2:Threshold		0.50 % to 100.00 %	15.00 %
_:17072:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:17072:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.31.4.4 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:17071:81	Stage 1:>Block stage	SPS	I
_:17071:54	Stage 1:Inactive	SPS	O
_:17071:52	Stage 1:Behavior	ENS	O
_:17071:53	Stage 1:Health	ENS	O
_:17071:55	Stage 1:Pickup	ACD	O
_:17071:56	Stage 1:Operate delay expired	ACT	O
_:17071:57	Stage 1:Operate	ACT	O
Stage 2			
_:17072:81	Stage 2:>Block stage	SPS	I
_:17072:54	Stage 2:Inactive	SPS	O
_:17072:52	Stage 2:Behavior	ENS	O
_:17072:53	Stage 2:Health	ENS	O
_:17072:55	Stage 2:Pickup	ACD	O
_:17072:56	Stage 2:Operate delay expired	ACT	O
_:17072:57	Stage 2:Operate	ACT	O

6.32 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

6.32.1 Overview of Functions

The Overvoltage protection with zero-sequence voltage/residual voltage function (ANSI 59N):

- Is used in isolated or arc-suppression-coil-grounded systems to detect ground faults
- determines the phase affected by the ground fault, if needed
- is used with electrical machines to detect ground faults in the stator winding.

6.32.2 Structure of the Function

The Overvoltage protection with zero-sequence voltage/residual voltage function is used in protection function groups, which are based on voltage measurement.

The Overvoltage protection with zero-sequence voltage/residual voltage function comes with 1 factory-set tripping stage. A maximum of 3 tripping stages can be operated simultaneously in the function.

The tripping stages have an identical structure.

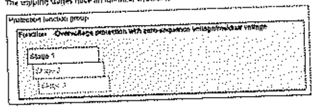

Figure 6-359 Structure/Embedding of the Function

6.32.3 Stage Description

Logic of a Stage

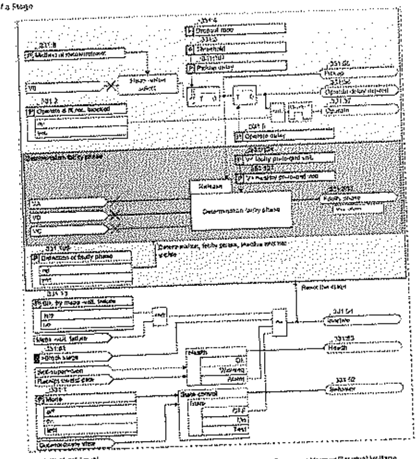

Figure 6-360 Logic Diagram of an Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage Stage

Measured Value, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V_0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V_0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

Use the Method of measurement parameter to select the relevant method of measurement, depending on the application.

- Measurement of the fundamental comp. (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value parameter value (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- fund. comp. long filter (fundamental component over 2 cycle filters with triangular window):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see Technical Data).

Pickup, Dropout

The stage compares the Threshold with the zero-sequence voltage V_0. The Pickup delay parameter allows you to delay the pickup of the stage depending on the residual voltage.

With the Dropout ratio parameter you can define the ratio of the dropout value to the Threshold.

Determination of the Faulty Phase

You can use the Detection of faulty phase parameter to enable or disable the determining of the phase affected by the ground fault. Determining is released when the stage picks up. If 2 phases exceed the threshold value V> healthy ph-to-gnd volt. and 1 phase falls below the threshold value V< faulty ph-to-gnd volt., the last phase is considered to be affected by the ground fault and is signaled as such.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal >Block stage from an external or internal source
- From inside on pick up of the measuring-voltage failure detection function (see chapter 8.3.2.1 Overview of Functions). The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal >Open of the function block Volt.-transf. c. b., which links in the tripping of the voltage-transformer circuit breaker. The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.32.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:331:8) Method of measurement = fundamental comp.

The Method of measurement parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.

Parameter Value	Description
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). Do not set the Threshold value of the tripping stage under 10 V for this method of measurement.
fund. comp. long filter	To implement particularly strong damping of harmonics and transient disturbances, select this method of measurement. At 2 periods, the length of the filter is longer than that of the standard filter. Please note that in this case the pickup time of the tripping level increases slightly (see Technical Data).

Parameter: Pickup delay

- Recommended setting value (_:331:107) Pickup delay = 0 ms

The Pickup delay parameter allows you to delay the analysis of the measurand (to generate the pickup) depending on the occurrence of the residual voltage. A pickup delay can be necessary if high transients are anticipated after fault inception due to high line and ground capacitances.

Siemens recommends using the default setting Pickup delay = 0 ms.

Parameter: Threshold

- Default setting (_:331:3) Threshold = 30 V[1]

The threshold value of the function is set as the zero-sequence voltage V_0. The device calculates the zero-sequence voltage V_0 either from the residual voltage measured via the broken-delta winding or from the 3 phase-to-ground voltages.

The setting value depends on the system grounding:

- Since virtually the full residual voltage occurs during ground faults in isolated or arc-suppression-coil-grounded systems, the setting value is uncritical there. It should range between 20 V and 40 V. A higher sensitivity (a lower threshold value) can be necessary for high fault resistances.
- You should select a more sensitive (smaller) value in a grounded system. This value must be higher than the maximum residual voltage anticipated during operation caused by system unbalances.

EXAMPLE

For an isolated system

The residual voltage is measured via the broken-delta windings:

- If the ground fault is fully unbalanced, a residual voltage of 100 V is present at the device terminals.
- The threshold value should be set so that the stage picks up to 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/√3 = 57.7 V
  Setting value: 0.5 · 57.7 V = 28.9 V ≈ 30 V

Parameter: Dropout ratio

- Recommended setting value (_:331:4) Dropout ratio = 0.95

The recommended set value of 0.95 is appropriate for most applications. The dropout ratio can be reduced, for example, to 0.98 to achieve a high measurement precision.

Parameter: Operate delay

- Default setting (_:331:6) Operate delay = 3.00 s

The Operate delay allows you to prevent transient residual voltages from initiating a trip. The setting depends on the specific application.

[1] [illegible]

Parameter: Blk. by meas. volt. failure

- Recommended setting value (_:331:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on.
- The binary input signal >Open of the function block VT CB is connected to the voltage-transformer circuit breaker (see Chapter 8.3.4.1 Overview of Functions).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Detection of faulty phase

- Default setting (_:331:106) Detection of faulty phase = no

The Detection of faulty phase parameter controls how the stage responds to determine which phase is affected by the ground fault.

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults. For example, applications in grounded systems.
yes	After a pickup by the residual voltage the device tries to determine, which phase is affected by the ground fault. Select this setting for applications in isolated or arc-suppression-coil-grounded systems.

Parameter: V< faulty ph-to-gnd volt.

- Default setting (_:331:101) V< faulty ph-to-gnd volt. = 30.000 V[2]

Set the threshold value for determining which phase is affected by the ground fault in the V< faulty ph-to-gnd volt. parameter. The setting value is a phase-to-ground quantity.

The set value must be smaller than the minimum phase-to-ground voltage occurring during operation.

Siemens recommends using the default setting V< faulty ph-to-gnd volt. = 30.000 V.

Parameter: V> healthy ph-to-gnd volt.

- Default setting (_:331:102) V> healthy ph-to-gnd volt. = 75.000 V[3]

Set the threshold value for the two healthy phases in the V> healthy ph-to-gnd volt. parameter. The setting value is a phase-to-ground quantity.

The set value must lie above the maximum phase-to-ground voltage occurring during operation, but below the minimum phase-to-phase voltage present during operation. At V_{rated} = 100 V, the value has to be set to 75 V, for example. Siemens recommends using the default setting V> healthy ph-to-gnd volt. = 75.000 V.

Operation as Supervision Function

If you want the stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

[2] The specific setting limits depend on the transformer data and transformer connections set.
[3] The specific setting limits depend on the transformer data and transformer connections set.

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6.32.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:331:1	Stage 1:Mode		• off • on • test	off
_:331:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:331:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:331:107	Stage 1:Detection of faulty phase		• no • yes	no
_:331:8	Stage 1:Method of measurement		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:331:3	Stage 1:Threshold		0.300 V to 340.000 V	30.000 V
_:331:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:331:107	Stage 1:Pickup delay		0.00 s to 320.00 s	0.00 s
_:331:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:331:101	Stage 1:V> healthy ph-to-gnd volt.		0.300 V to 340.000 V	75.000 V
_:331:104	Stage 1:V< faulty ph-to-gnd volt.		0.300 V to 340.000 V	40.000 V

6.32.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:331:81	Stage 1:>Block stage	SPS	I
_:331:54	Stage 1:Inactive	SPS	O
_:331:52	Stage 1:Behavior	ENS	O
_:331:53	Stage 1:Health	ENS	O
_:331:306	Stage 1:Faulty phase	ACT	O
_:331:55	Stage 1:Pickup	ACD	O
_:331:56	Stage 1:Operate delay expired	ACT	O
_:331:57	Stage 1:Operate	ACT	O

6.33 Overvoltage Protection with Any Voltage

6.33.1 Overview of Functions

The function Overvoltage protection with any voltage (ANSI 59) detects any 1-phase overvoltages and is intended for special applications.

6.33.2 Structure of the Function

The Overvoltage protection with any voltage function is used in protection function groups, which are based on voltage measurement.

The function Overvoltage protection with any voltage comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

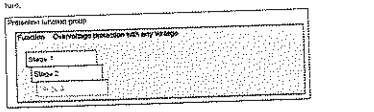

Figure 6-361 Structure/Embedding of the Function

6.33.3 Stage Description

Logic of a Stage

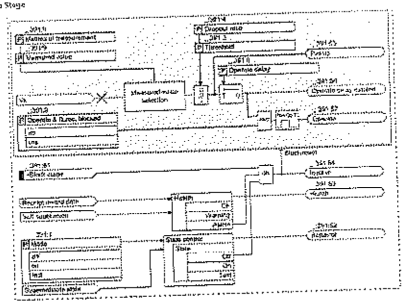

Figure 6-362 Logic Diagram of a Stage: Overvoltage Protection with Any Voltage

> **NOTE**
> If the function Overvoltage protection with any voltage is used in a 1-phase function group, the parameter Measured value is not visible.

Method of Measurement

The Method of measurement parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the fundamental comp.:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the parameter value RMS value
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter Measured value allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function Overvoltage protection with any voltage is used in a 1-phase function group, the parameter Measured value is not visible.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking is possible externally or internally via the binary input signal >Block stage.

6.33.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:391:8) Method of measurement = fundamental comp.

Use the Method of measurement parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends this method of measurement as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the threshold value of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting (_:391:9) Measured value = VA measured

The Measured value parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the Appendix.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (VA measured)
- Measured phase-to-ground voltage V_B (VB measured)
- Measured phase-to-ground voltage V_C (VC measured)
- Measured phase-to-phase voltage V_{AB} (VAB measured)
- Measured phase-to-phase voltage V_{BC} (VBC measured)
- Measured phase-to-phase voltage V_{CA} (VCA measured)
- Calculated phase-to-phase voltage V_{AB} (VAB calculated)
- Calculated phase-to-phase voltage V_{BC} (VBC calculated)
- Calculated phase-to-phase voltage V_{CA} (VCA calculated)
- Calculated voltage V0 (V0 calculated)

The selection depends on the corresponding application.

> **NOTE**
> If the function Overvoltage protection with any voltage is used in a 1-phase function group, the parameter Measured value is not visible.

Parameter: Threshold

- Default setting (_:391:3) Threshold = 110 V

Specify the Threshold (pickup threshold) for the specific application.

Depending on the measured value, the Threshold is set either as Measured voltage or as Phase-to-phase quantity.

Parameter: Operate delay

- Default setting (_:391:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:391:4) Dropout ratio = 0.95

The recommended set value of 0.95 is appropriate for most applications. To achieve high measurement precision, the Dropout ratio can be reduced, to 0.98, for example.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

6.33.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:391:1	Stage 1:Mode		• off • on • test	off
_:391:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:391:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:391:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:391:3	Stage 1:Threshold		0.300 V to 340.000 V	110.000 V
_:391:4	Stage 1:Dropout ratio		0.90 to 0.99	0.95
_:391:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:392:1	Stage 2:Mode		• off • on • test	off
_:392:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:392:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:392:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:392:3	Stage 2:Threshold		0.300 V to 340.000 V	130.000 V
_:392:4	Stage 2:Dropout ratio		0.90 to 0.99	0.95
_:392:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.33.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:391:81	Stage 1:>Block stage	SPS	I
_:391:54	Stage 1:Inactive	SPS	O
_:391:52	Stage 1:Behavior	ENS	O
_:391:53	Stage 1:Health	ENS	O
_:391:55	Stage 1:Pickup	ACD	O
_:391:56	Stage 1:Operate delay expired	ACT	O
_:391:57	Stage 1:Operate	ACT	O
Stage 2			
_:392:81	Stage 2:>Block stage	SPS	I
_:392:54	Stage 2:Inactive	SPS	O
_:392:52	Stage 2:Behavior	ENS	O
_:392:53	Stage 2:Health	ENS	O
_:392:55	Stage 2:Pickup	ACD	O
_:392:56	Stage 2:Operate delay expired	ACT	O
_:392:57	Stage 2:Operate	ACT	O

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6.34 Undervoltage Protection with 3-Phase Voltage

6.34.1 Overview of Functions

The function Undervoltage protection with 3-phase voltage (ANSI 27) is used to:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components and machines) against damages caused by undervoltage
- Handle disconnection or load shedding tasks in a system

6.34.2 Structure of the Function

The Undervoltage protection with 3-phase voltage function is used in protection function groups with voltage measurement.
The Undervoltage protection with 3-phase voltage function is preconfigured by the manufacturer with 2 Definite time-undervoltage protection stages.
In the function Undervoltage protection with 3-phase voltage, the following stages can be operated simultaneously:

- 3 stages Definite time-undervoltage protection
- 2 stages Inverse time-undervoltage protection

Stages that are not preconfigured are shown in gray in the following figure.
The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see Figure 6-363). If the protection function group used has no current measurement, you can only set the current-flow criterion as fulfilled via the corresponding binary input signal.

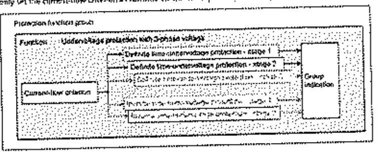

Figure 6-363 Structure/Embedding of the Function

6.34.3 Stage with Definite-Time Characteristic Curve

6.34.3.1 Description

Logic of a Stage

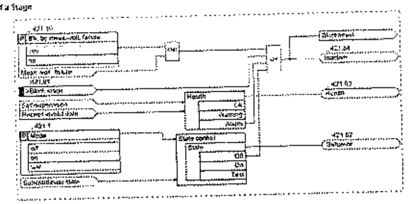

Figure 6-364 Logic Diagram of the Stage Control

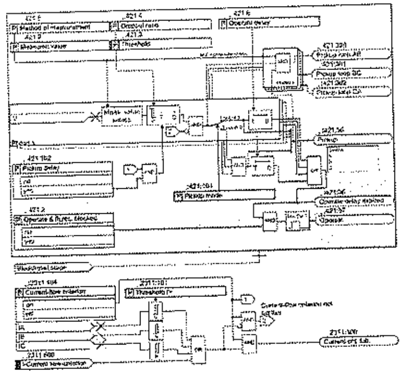

Figure 6-365 Logic Diagram of the Function

Method of Measurement

With the Method of measurement parameter, you select the relevant method of measurement, depending on the application:

- Measurement fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

With the Measured value parameter, you define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA} or the phase-to-ground voltages V_A, V_B, and V_C.
If the measured value is set to phase-to-phase, the function reports three measuring elements that have picked up.

Pickup Mode

With the Pickup mode setting, you define whether the stage picks up when there is a lower threshold-value violation in one measuring element (1 out of 3) or when there is a lower threshold-value violation in all 3 measuring elements (3 out of 3).

Pickup Delay

The Pickup delay parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter Current-flow criterion = on).
If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the Pickup delay parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The Current-flow criterion works across all tripping stages.
When the Current-flow criterion parameter is activated, the undervoltage protection stages only pick up if a settable minimum current (Threshold I>) is exceeded. A current below the minimum current blocks the stages.
The current-flow criterion can also be set to fulfilled with the binary input signal >Current flow-criterion. The function reports when the current-flow criterion is fulfilled.
Figure 6-365 illustrates the influence of the current-flow criterion.

NOTE

If the (_:2311:104) Current-flow criterion parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked-up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal >Block stage from an external or internal source
- From inside on pickup of the measuring-voltage failure detection function (see section 8.3.2 Overview of Functions). The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal >Open of the function block Volt.-transf. c. b., which links in the tripping of the voltage-transformer circuit breaker. The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.34.3.2 Application and Setting Notes

Parameter: Pickup mode

- Recommended setting value (_:421:101) Pickup mode = 1 out of 3

With the Pickup mode parameter, you specify whether the stage picks up when there is a lower threshold-value violation in one measuring element (1 out of 3) or when there is a lower threshold-value violation in all 3 measuring elements (3 out of 3).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends 1 out of 3 as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting (_:421:102) Pickup delay = no

The Pickup delay parameter is only available if you are using the current-flow criterion of the function (parameter Current-flow criterion = on). If the current-flow criterion is deactivated, no pickup delay is required.
With the parameter Pickup delay you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for undervoltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

6.34.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Definite-T 1				
_:421:1	Definite-T 1:Mode		• off • on • test	off
_:421:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:421:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:421:9	Definite-T 1:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:421:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.

Addr.	Parameter	C	Setting Options	Default Setting
_:421:101	Definite-T 1:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:421:102	Definite-T 1:Pickup delay		• no • yes	no
_:421:3	Definite-T 1:Threshold		0.300 V to 175.000 V	80.000 V
_:421:4	Definite-T 1:Dropout ratio		1.01 to 1.20	1.05
_:421:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	3.00 s
Definite-T 2				
_:422:1	Definite-T 2:Mode		• off • on • test	off
_:422:2	Definite-T 2:Operate & flt.rec. blocked		• no • yes	no
_:422:10	Definite-T 2:Blk. by meas.-volt. failure		• no • yes	yes
_:422:9	Definite-T 2:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:422:8	Definite-T 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:422:101	Definite-T 2:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:422:102	Definite-T 2:Pickup delay		• no • yes	no
_:422:3	Definite-T 2:Threshold		0.300 V to 175.000 V	65.000 V
_:422:4	Definite-T 2:Dropout ratio		1.01 to 1.20	1.05
_:422:6	Definite-T 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.34.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow criterion	SPS	I
_:2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:421:81	Definite-T 1:>Block stage	SPS	I
_:421:54	Definite-T 1:Inactive	SPS	O
_:421:52	Definite-T 1:Behavior	ENS	O
_:421:53	Definite-T 1:Health	ENS	O
_:421:55	Definite-T 1:Pickup	ACD	O
_:421:300	Definite-T 1:Pickup loop AB	SPS	O
_:421:301	Definite-T 1:Pickup loop BC	SPS	O
_:421:302	Definite-T 1:Pickup loop CA	SPS	O

No.	Information	Data Class (Type)	Type
_:421:56	Definite-T 1:Operate delay expired	ACT	O
_:421:57	Definite-T 1:Operate	ACT	O
Definite-T 2			
_:422:81	Definite-T 2:>Block stage	SPS	I
_:422:54	Definite-T 2:Inactive	SPS	O
_:422:52	Definite-T 2:Behavior	ENS	O
_:422:53	Definite-T 2:Health	ENS	O
_:422:55	Definite-T 2:Pickup	ACD	O
_:422:300	Definite-T 2:Pickup loop AB	SPS	O
_:422:301	Definite-T 2:Pickup loop BC	SPS	O
_:422:302	Definite-T 2:Pickup loop CA	SPS	O
_:422:56	Definite-T 2:Operate delay expired	ACT	O
_:422:57	Definite-T 2:Operate	ACT	O

6.34.4 Stage with Inverse-Time Characteristic Curve

6.34.4.1 Description

Logic

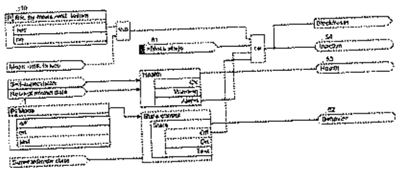

Figure 6-366 Logic Diagram of the Stage Control

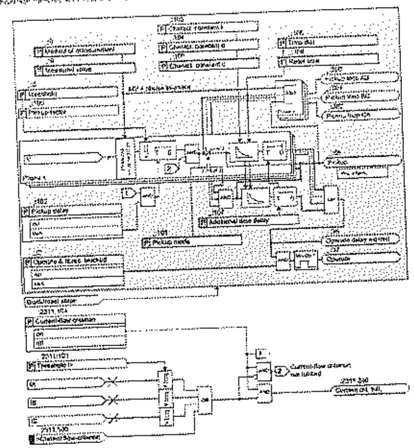

Figure 6-367 Logic Diagram of the Function

Method of Measurement

Use the Method of measurement parameter to define whether the stage uses the fundamental comp. or the RMS value.

- Measurement fundamental comp.:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

Use the Measured value parameter to define whether the stage analyzes the phase-to-phase voltages V_{AB}, V_{BC} and V_{CA} or the phase-to-ground voltages V_A, V_B and V_C.

If the measured value is set to phase-to-phase, the function reports those measuring elements that have picked up.

Pickup Mode

Use the Pickup mode parameter to define whether the stage picks up when there is a lower threshold value violation in one measuring element (1 out of 3) or when there is a lower threshold value violation in all 3 measuring elements (3 out of 3).

Pickup and Operate Curve

When the input voltage falls below the threshold value by a settable value Pickup factor, the stage picks up and the inverse-time characteristic curve is processed. The operate delay starts. The operate delay is the sum of inverse-time delay and additional time delay.

$T_{op} = T_{inv} + T_{Add}$

Where:

T_{op}	Operate delay
T_{inv}	Inverse-time delay
T_{Add}	Additional time delay (Parameter Additional time delay)

After pickup the time value T_{inv} is calculated for every input voltage less than the dropout value. An integrator accumulates the value $1/T_{inv}$. When the accumulated integral reaches the fixed value 1, the inverse-time delay expires. The stage operates after the additional time delay.

The inverse-time delay is calculated with the following formula:

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

Where

T_{inv}	Inverse-time delay
T_p	Time multiplier (Parameter Time dial)
V	Measured undervoltage
V_{thresh}	Threshold value (Parameter Threshold)
k	Curve constant k (Parameter Charact. constant k)
α	Curve constant α (Parameter Charact. constant α)
c	Curve constant c (Parameter Charact. constant c)

The inverse-time characteristic is shown in the following figure:

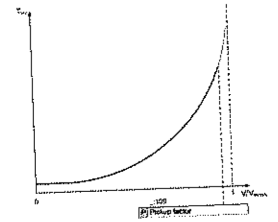

Figure 6-368 Inverse-Time Characteristic for Undervoltage Protection

Pickup Delay

The Pickup delay parameter is only available and of relevance if you are using the Current-flow criterion of the function (parameter Current-flow criterion = yes).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout time can conflict with one another. Depending on the threshold value setting for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the stage picks up briefly. Use the Pickup delay parameter to prevent the stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Dropout Behavior

When the voltage exceeds the dropout value (1.05 x pickup factor x threshold value), the pickup signal is going and the dropout is started. You can define the dropout behavior via parameter Reset time. Instantaneous reset takes place by setting Reset time to 0 s. A delayed reset takes place by setting the desired delay time.

During the reset time (> 0 s), the elapsed operate delay is frozen. If the stage picks up again within this period, the stage operates when the rest of operate delay expires.

Current-Flow Criterion

The undervoltage protection stages work optionally with a current-flow criterion. The Current-flow criterion works across all tripping stages.

When the Current-flow criterion parameter is activated, the undervoltage-protection stages only pick up if a settable minimum current (Threshold I>) is exceeded. A current below the minimum current blocks the stages.

The current-flow criterion can also be set to fulfilled with the binary input signal >Current flow-criterion. The function reports when the current-flow criterion is fulfilled.

Figure 6-367 illustrates the influence of the current-flow criterion.

NOTE

If the (_:2311:104) Current-flow criterion parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage is reset. The following blocking options are available for the stage:

- Via the binary input signal >Block stage from an external or internal source
- From inside on pickup of the Measuring-voltage failure detection function (see chapter 8.3.2.1 Overview of Functions). The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.
- From an external source via the binary input signal >Open of the function block Volt.-transf. c. b., which links in the tripping of the voltage-transformer circuit breaker. The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.34.4.2 Application and Setting Notes

Parameter: Pickup mode

- Recommended setting value (_:101) Pickup mode = 1 out of 3

With the Pickup mode parameter, you specify whether the stage picks up when there is a lower threshold value violation in one measuring element (1 out of 3) or when there is a lower threshold value violation in all 3 measuring elements (3 out of 3).

Parameter Value	Description
1 out of 3	Use this setting for protection applications or for monitoring the voltage range. Siemens recommends 1 out of 3 as the default setting. This reflects how the function behaved in previous generations (SIPROTEC 4, SIPROTEC 3).
3 out of 3	Select this setting when using the stage to disconnect from the power system (in the case of wind farms, for example).

Parameter: Pickup delay

- Default setting (_:102) Pickup delay = no

The Pickup delay parameter is only available if you are using the current-flow criterion of the function (parameter Current-flow criterion = on). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter Pickup delay, you set whether pickup of the stage is to be delayed by approximately 40 ms or not. This delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the stage, depending on the threshold-value settings for undervoltage and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.

Parameter Value	Description
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Charact. constant k, Charact. constant α, Charact. constant c

- Default setting (_:103) Charact. constant k = 1.00
- Default setting (_:104) Charact. constant α = 1.000
- Default setting (_:105) Charact. constant c = 0.000

With the Charact. constant k, Charact. constant α, and Charact. constant c parameters, you define the required inverse-time characteristic.

Parameter: Time dial

- Default setting (_:106) Time dial = 1.00

With the Time dial parameter, you displace the characteristic curve in the time direction.

As usually, there is no time grading for voltage protection and therefore no displacement of the characteristic curve. Siemens recommends leaving the Time dial parameter at 1.00 (default setting).

Parameter: Reset time

- Default setting (_:108) Reset time = 0.00 s

With the Reset time parameter, you define the reset time delay which is started when the voltage exceeds the dropout value. Set the parameter Reset time to 0 s when instantaneous reset is desired.

Under network conditions of intermittent faults or faults which occur in rapid succession, Siemens recommends setting the Reset time to an appropriate value > 0 s to ensure the operation. Otherwise, Siemens recommends to keep the default value to ensure a fast reset of the function.

Parameter: Additional time delay

- Default setting (_:107) Additional time delay = 0.00 s

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay.

If the setting is left on its default value of 0 s, only the inverse-time delay is operative.

6.34.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T #				
_:1	Inverse-T #:Mode		• off • on • test	off
_:2	Inverse-T #:Operate & flt.rec. blocked		• no • yes	no
_:10	Inverse-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:8	Inverse-T #:Measured value		• phase-to-ground • phase-to-phase	phase-to-phase
_:8	Inverse-T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:101	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3

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Addr.	Parameter	C	Setting Options	Default Setting
_:102	Inverse-T #:Pickup delay		• no • yes	no
_:3	Inverse-T #:Threshold		0.300 V to 175.000 V	80.000 V
_:109	Inverse-T #:Pickup factor		0.80 to 1.00	0.90
_:103	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:104	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:105	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:106	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:107	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:108	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.34.4.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T #			
_:81	Inverse-T #:>Block stage	SPS	I
_:54	Inverse-T #:Inactive	SPS	O
_:52	Inverse-T #:Behavior	ENS	O
_:53	Inverse-T #:Health	ENS	O
_:55	Inverse-T #:Pickup	ACD	O
_:300	Inverse-T #:Pickup loop AB	SPS	O
_:301	Inverse-T #:Pickup loop BC	SPS	O
_:302	Inverse-T #:Pickup loop CA	SPS	O
_:56	Inverse-T #:Operate delay expired	ACT	O
_:57	Inverse-T #:Operate	ACT	O

6.35 Undervoltage Protection with Positive-Sequence Voltage

6.35.1 Overview of Functions

The Undervoltage protection with positive-sequence voltage function (ANSI 27) is used for:

- Monitor the permissible voltage range
- Protect equipment (for example, plant components and machines) from damage caused by undervoltage
- Protect motors and generators from inadmissible operating states and a possible loss of stability in the event of voltage dips

2-phase short circuits or ground faults lead to an unbalanced voltage collapse. In comparison to phase 1-phase measuring systems, such events have no noticeable impact on the positive-sequence voltage. This makes this function particularly suitable for the assessment of stability problems.

6.35.2 Structure of the Function

The Undervoltage protection with positive-sequence voltage function is used in protection function groups, which are based on voltage measurement.

The Undervoltage protection with positive-sequence voltage function comes with 2 factory-set tripping stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see Figure 6-369). If the protection function group used has no current measurement, you can only set the current-flow criterion as fulfilled via the corresponding binary input signal.

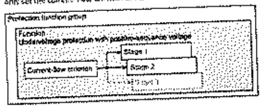

Figure 6-369 Structure/Embedding of the Function

6.35.3 Stage Description

Logic of a Stage

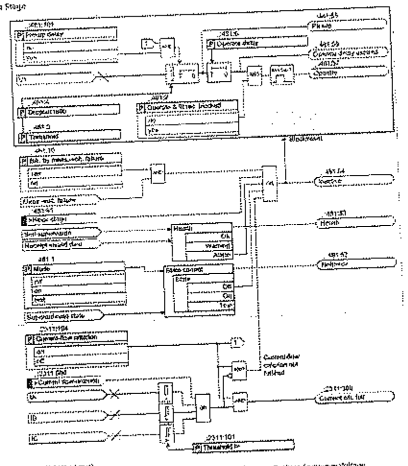

Figure 6-370 Logic Diagram of a Stage: Undervoltage Protection with Positive-Sequence Voltage

Method of Measurement

The stage uses the positive-sequence voltage. The positive-sequence voltage is calculated from the measured phase-to-ground voltages according to the defining equation.

Pickup Delay

The Pickup delay parameter is only available and of relevance if you are using the current-flow criterion of the function (parameter Current-flow criterion = on).

If the circuit breaker opens when the current-flow criterion is being used, the undervoltage detection and current-flow dropout functions conflict with one another. Depending on the threshold-value settings for undervoltage detection and current-flow criterion, it is possible that the undervoltage is detected before the current-flow criterion has dropped out. In this case, the tripping stage picks up briefly. Use the Pickup delay parameter to prevent the tripping stage from briefly picking up in this way when the circuit breaker opens. This is achieved by delaying pickup by approximately 40 ms.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the Current-flow criterion parameter is activated, the undervoltage protection stages only pick up if a settable minimum current (Threshold I>) is exceeded in at least one phase. A current below the minimum current blocks the tripping stages.

The current-flow criterion can also be set to fulfilled with the binary input signal >Current flow criterion. The function reports when the current-flow criterion is fulfilled.

Figure 6-370 illustrates the influence of the current-flow criterion.

> **NOTE**
> If the Current-flow criterion parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- Via the binary input signal >Block stage from an external or internal source
- From inside on pickup of the Measuring-voltage failure detection function (see chapter 8.3.2.1 Overview of Functions). The Blk. by meas.-volt. failure parameter can be set to either block or not block the tripping stage when the measuring-voltage failure detection picks up.
- From an external source via the binary input signal >Open of the function block Volt.-transf. c. b., which links in the tripping of the voltage-transformer circuit breaker. The Blk. by meas.-volt. failure parameter can be set so that measuring-voltage failure detection blocks the stage or does not block it.

6.35.4 Application and Setting Notes

Parameter: Threshold

- Default setting (_:481:3) Threshold = 46 V

Specify the Threshold (pickup threshold) for the specific application. For the default setting, it has been assumed that the lowest voltage stage, that is, 80 % of the rated voltage of the protected object, is to be monitored.

Parameter: Pickup delay

- Default setting (_:481:101) Pickup delay = no

The Pickup delay parameter is only available if you are using the current-flow criterion of the function (parameter Current-flow criterion = on). If the current-flow criterion is deactivated, no pickup delay is required.

With the parameter Pickup delay you set whether pickup of the stage is to be delayed by approximately 40 ms or not. The delay avoids possible brief pickup of the stage when the circuit breaker opens.

Parameter Value	Description
no	Use this setting if you definitely do not want tripping stage pickup to be subject to a time delay in the event of a fault. This setting results in pickup and, where applicable, tripping being performed as quickly as possible. Note that switching procedures (opening of the CB) can result in brief pickup of the tripping stage, depending on the threshold-value settings for undervoltage pickup and the current-flow criterion. To prevent unwanted tripping, you must set a minimum tripping delay of 50 ms.
yes	Use this setting when switching procedures (opening of the CB) are not permitted to result in tripping-stage pickup. Note that pickup is delayed by approximately 40 ms. This delay is added to the operate time.

Parameter: Operate delay

- Default setting (_:481:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:481:4) Dropout ratio = 1.05

The recommended setting value of 1.05 is sufficient for many applications. To obtain extremely accurate indications, the Dropout ratio can be reduced.

Parameter: Blk. by meas.-volt. failure

- Default setting (_:481:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following two conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on.
- The binary input signal >Open of the function block VT CB is connected to the voltage-transformer circuit breaker (see chapter 8.3.4.1 Overview of Functions).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.
no	The protection stage is not blocked.

Parameter: Current-flow criterion

- Recommended setting value (_:2311:104) Current-flow criterion = on

Depending on the system, the voltage transformers can be located on the supply or the outgoing side. These 2 possible voltage-transformer locations induce a different behavior of the function after tripping and opening of the circuit breaker.

- If they are located on the supply side, the voltage remains on.
- If they are located on the output side, the voltage is switched off.

Parameter Value	Description
on	The current-flow criterion allows to achieve, in the case of voltage transformers located on the output side, that the pickup drops out when the current drops below a minimum value (parameter Threshold I> value).

Parameter Value	Description
off	Since the voltage is switched off, the pickup of the undervoltage-protection stage persists when the current-flow criterion is not used.

Parameter: Threshold I>

- Recommended setting value (_:2311:101) Threshold I> = 0.05 A

The parameter Threshold I> makes it possible to detect when the circuit-breaker is closed. We recommend that you set the Threshold I> parameter to 5 % of the rated current. With a secondary rated transformer current of 1 A, the secondary setting value for Threshold I> would be 0.05 A.

If the sensitivity of the Threshold I> parameter is set too high, commutation processes in the secondary circuit of the current transformer can extend the dropout time when breaking extremely high currents. To speed up dropout, increase the default setting.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

6.35.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:104	General:Current-flow criterion		• off • on	on
_:2311:101	General:Threshold I>	1 A @ 100 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
Stage 1				
_:481:1	Stage 1:Mode		• off • on • test	off
_:481:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:481:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:481:101	Stage 1:Pickup delay		• no • yes	no
_:481:3	Stage 1:Threshold		0.300 V to 200.000 V	46.000 V
_:481:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05
_:481:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:482:1	Stage 2:Mode		• off • on • test	off
_:482:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:482:10	Stage 2:Blk. by meas.-volt. failure		• no • yes	yes

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Addr.	Parameter	C	Setting Options	Default Setting
_482:101	Stage 2:Pickup delay		• no • yes	no
_482:3	Stage 2:Threshold		0.300 V to 200.000 V	40.000 V
_482:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_482:6	Stage 2:Operate delay		0.00 s to 60.00 s	[illegible]

6.35.6 Information List

No.	Information	Data Class (Type)	Type
General			
_2311:500	General:>Current flow criterion	SPS	I
_2311:300	General:Current crit. fulf.	SPS	O
Group indicat.			
_4501:55	Group indicat.:Pickup	ACD	O
_4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_481:81	Stage 1:>Block stage	SPS	I
_481:54	Stage 1:Inactive	SPS	O
_481:52	Stage 1:Behavior	ENS	O
_481:53	Stage 1:Health	ENS	O
_481:55	Stage 1:Pickup	ACD	O
_481:56	Stage 1:Operate delay expired	ACT	O
_481:57	Stage 1:Operate	ACT	O
Stage 2			
_482:81	Stage 2:>Block stage	SPS	I
_482:54	Stage 2:Inactive	SPS	O
_482:52	Stage 2:Behavior	ENS	O
_482:53	Stage 2:Health	ENS	O
_482:55	Stage 2:Pickup	ACD	O
_482:56	Stage 2:Operate delay expired	ACT	O
_482:57	Stage 2:Operate	ACT	O

6.36 Undervoltage Protection with Any Voltage

6.36.1 Overview of Functions

The function Undervoltage protection with any voltage (ANSI 27) detects any 1-phase undervoltage and is intended for special applications.

6.36.2 Structure of the Function

The Undervoltage protection with any voltage function is used in protection function groups, which are based on voltage measurement.

The function Undervoltage protection with any voltage comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The protection function is structured such that one current-flow criterion can act on all undervoltage protective stages (see Figure 6-371).

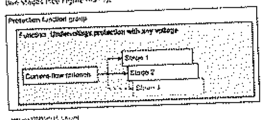

Figure 6-371 Structure/Embedding of the Function

6.36.3 Stage Description

Logic of a Stage

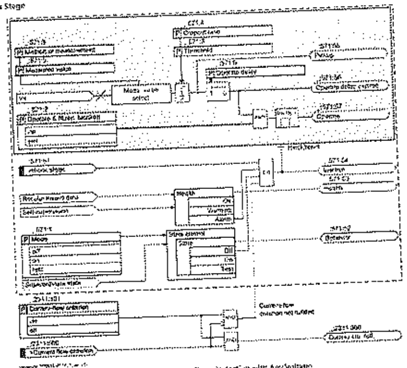

Figure 6-372 Logic Diagram of a Stage: Undervoltage Protection with Any Voltage

> **NOTE**
> If the function is used in 1-phase function groups, the parameter Measured value is not available.

Method of Measurement

The Method of measurement parameter allows you to define whether the function works with the fundamental component or the calculated RMS value.

- Measurement of the fundamental component:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value:
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value. Harmonics are included in the analysis.

Measured Value

The parameter Measured value allows you to select whether the stage uses a measured (directly connected) voltage or a calculated phase-to-phase voltage.

If the function is used in 1-phase function groups, the parameter Measured value is not available.

Current-Flow Criterion

The undervoltage-protection stages work optionally with a current-flow criterion. The current-flow criterion works across all stages.

When the Current-flow criterion parameter is switched on, the undervoltage protection stages only pick up when the current-flow criterion has been set to fulfilled via the binary input signal >Current flow criterion. The function reports when the current-flow criterion is fulfilled.

Figure 6-372 illustrates the influence of the current-flow criterion.

> **NOTE**
> If the (_:2311:101) Current-flow criterion parameter is deactivated, the device picks up immediately if a missing measuring voltage is detected while the undervoltage protection is active. The parameter setting can be changed even when the device has picked up.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal >Block stage.

6.36.4 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:571:8) Method of measurement = fundamental comp.

Use the Method of measurement parameter to define whether the tripping stage uses the fundamental component (standard method = default setting) or the calculated RMS value.

Parameter Value	Description
fundamental comp.	Select this method of measurement to suppress harmonics or transient voltage peaks. Siemens recommends using this parameter value as the default setting.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks). Do not set the threshold value of the tripping stage under 10 V for this method of measurement.

Parameter: Measured value

- Default setting (_:571:9) Measured value = VA measured

The Measured value parameter is used to specify which voltage is monitored by the stage.

The scope of setting options depends on the connection type for the voltage transformers and the routing of the measured values to the terminals of the voltage measuring point. You can find connection examples for voltage transformers in the Appendix.

The following setting options can be available:

- Measured phase-to-ground voltage V_A (VA measured)
- Measured phase-to-ground voltage V_B (VB measured)
- Measured phase-to-ground voltage V_C (VC measured)
- Measured phase-to-phase voltage V_{AB} (VAB measured)

- Measured phase-to-phase voltage V_{BC} (VBC measured)
- Measured phase-to-phase voltage V_{CA} (VCA measured)
- Calculated phase-to-phase voltage V_{AB} (VAB calculated)
- Calculated phase-to-phase voltage V_{BC} (VBC calculated)
- Calculated phase-to-phase voltage V_{CA} (VCA calculated)
- Calculated voltage V0 (V0 calculated)

The selection depends on the corresponding application.

> **NOTE**
> If the function is used in 1-phase function groups, the parameter Measured value is not available.

Parameter: Threshold

- Default setting (_:571:3) Threshold = 40 V

Specify the Threshold (pickup threshold) for the specific application.

Depending on the Measured value, the Threshold is set either as measured voltage or as a phase-to-phase variable.

Parameter: Operate delay

- Default setting (_:571:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:571:4) Dropout ratio = 1.05

The recommended set value of 1.05 is appropriate for most applications. To achieve high measurement precision, the Dropout ratio can be reduced to 1.02, for example.

Parameter: Current-flow criterion

- Recommended setting value (_:2311:101) Current-flow criterion = on

Parameter Value	Description
on	Because of the application, it makes sense that the stage is only active (that is, not blocked) when a certain current flow is present (see note).
off	Current-flow monitoring does not make sense for the application.

> **NOTE**
> Because of the flexible setting options of the voltage measurand, the function itself does not determine the current associated with the voltage. A suitable current-flow monitoring function must be created by the user with the Continuous Function Chart (CFC) and connected to the binary input signal >Current flow criterion.

Operation as Supervision Function

If you want the tripping stage to have a reporting effect only, generation of the operate indication and fault logging can be disabled via the Operate & flt.rec. blocked parameter.

6.36.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Current-flow criterion		• off • on	on
Stage 1				
_:571:1	Stage 1:Mode		• off • on • test	off
_:571:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:571:9	Stage 1:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:571:8	Stage 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:571:3	Stage 1:Threshold		0.300 V to 340.000 V	80.000 V
_:571:4	Stage 1:Dropout ratio		1.01 to 1.20	1.05
_:571:6	Stage 1:Operate delay		0.00 s to 60.00 s	3.00 s
Stage 2				
_:572:1	Stage 2:Mode		• off • on • test	off
_:572:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:572:9	Stage 2:Measured value		• VA measured • VB measured • VC measured • VAB measured • VBC measured • VCA measured • VAB calculated • VBC calculated • VCA calculated • V0 calculated	VA measured
_:572:8	Stage 2:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:572:3	Stage 2:Threshold		0.300 V to 340.000 V	65.000 V
_:572:4	Stage 2:Dropout ratio		1.01 to 1.20	1.05
_:572:6	Stage 2:Operate delay		0.00 s to 60.00 s	0.50 s

6.36.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Current flow-direction	SPS	I
_:2311:300	General:Current dir. fail	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:571:81	Stage 1:>Block stage	SPS	I
_:571:54	Stage 1:Inactive	SPS	O
_:571:52	Stage 1:Behavior	ENS	O
_:571:53	Stage 1:Health	ENS	O
_:571:55	Stage 1:Pickup	ACD	O
_:571:56	Stage 1:Operate delay expired	ACT	O
_:571:57	Stage 1:Operate	ACT	O
Stage 2			
_:572:81	Stage 2:>Block stage	SPS	I
_:572:54	Stage 2:Inactive	SPS	O
_:572:52	Stage 2:Behavior	ENS	O
_:572:53	Stage 2:Health	ENS	O
_:572:55	Stage 2:Pickup	ACD	O
_:572:56	Stage 2:Operate delay expired	ACT	O
_:572:57	Stage 2:Operate	ACT	O

6.37 Undervoltage-Controlled Reactive-Power Protection

6.37.1 Overview of Functions

The Undervoltage-controlled reactive-power protection function (ANSI 27/Q):

- Detects critical power system situations, mainly in case of regenerative generation
- Prevents a voltage collapse in power system by disconnecting the power-generation facility from the main power systems
- Ensures reconnection under stable power-system conditions

6.37.2 Structure of the Function

The Undervoltage-controlled reactive-power protection function can be used in protection function groups containing 3-phase voltage and current measurement. Depending on the device, it is preconfigured by the manufacturer with 1 Protection stage and 1 Reclosure stage. A maximum of 2 Protection stages and 1 Reclosure stage can operate simultaneously within the function.

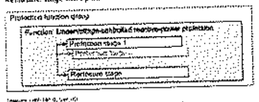

Figure 6-373 Structure/Embedding of the Function

6.37.3 Description Protection Stage

6.37.3.1 Description

Logic of the Stage

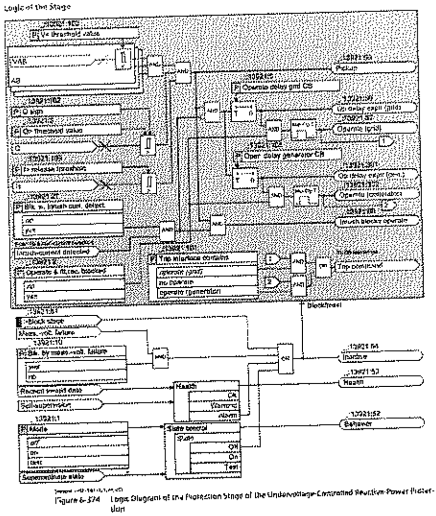

Figure 6-374 Logic Diagram of the Protection Stage of the Undervoltage-Controlled Reactive-Power Protection

Measurand

To detect critical power-system situations, the Undervoltage-controlled reactive-power protection function uses the fundamental values of the phase-to-phase voltages, the positive-sequence current, and the reactive power.

Q-Measurement Direction

The default directions of the positive reactive-power flow Q and the forward direction of the short-circuit protection are identical, in the direction of the protected object. Via parameter Q sign, the direction of the positive reactive-power flow Q can be changed by inverting the sign of the reactive power Q.

Pickup

The protection stage picks up under the following conditions:

- All 3 phase-to-phase voltages are below the parameterized threshold value.
- The positive-sequence current I_1 is above the parameterized threshold value.
- The power-generation facility requires more than the parameterized reactive power (Q is above the parameterized threshold value).

Trip Interface

The stage provides 2 operate signals, the *Operate (generator)* and the *Operate (grid)*. Depending on the parameter Trip interface contains, one or none of them will be forwarded to the trip interface of the circuit-breaker interaction.

Blocking of the Stage

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal >Block stage
- Measuring-voltage failure

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter permits you to define whether the operate delay should be blocked by a threshold-value violation due to an inrush current.

For further information about device-internal inrush-current detection function, refer to chapter 6.56.7.1 Description.

6.37.3.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:13921:10) Blk. by meas.-volt. failure = yes

You use the Blk. by meas.-volt. failure parameter to control the response of the stage when a measuring-voltage failure is detected.

A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal Measuring-voltage failure detection function is configured and switched on.
- The binary input signal >Open of the function block Voltage-transformer circuit breaker is connected to the voltage-transformer circuit breaker.

Parameter Value	Description
yes	The Protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as there is no assurance that the Protection stage will function correctly if the measuring voltage fails.
no	The Protection stage is not blocked when a measuring-voltage failure is detected.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:13921:27) Blk. w. inrush curr. detect. = no

You use the Blk. w. inrush curr. detect. parameter to determine whether the operate delay and operate signal are blocked during the detection of an inrush current.

Parameter: I> release threshold

- Recommended setting value (_:13921:105) I> release threshold = 0.100 A

You use the I> release threshold parameter to define a precondition that the stage can pick up. The default setting is at 10 % of the rated current. Siemens recommends using the default setting.

Parameter: Vc threshold value

- Recommended setting value (_:13921:103) Vc threshold value = 85.000 V

You use the Vc threshold value parameter to define one of the 2 pickup criteria. If all 3 phase-to-phase voltages drop below the parameterized undervoltage threshold value, the pickup criterion is fulfilled.

The setting should be set below the lower value of the permissible voltage range, according to the national transmission code. In Germany, the recommended undervoltage threshold is 85 % of the rated voltage. Therefore Siemens recommends using the default setting.

Parameter: Q> threshold value

- Default setting (_:13921:3) Q> threshold value = 5 %

You use the Q> threshold value parameter to define the second of the 2 pickup criteria. If the positive reactive power exceeds the parameterized Q> threshold value, the pickup criterion is fulfilled.

In the following example, the pickup takes place if Q exceeds 5 % of the power-supply system rated power.

> **EXAMPLE**
>
> The following example is given for settings in secondary values.
>
> Rated voltage: $V_{rated,sec}$ = 100 V
>
> Rated current: $I_{rated,sec}$ = 1 A
>
> Threshold value: 5 % of the power-supply system rated power
>
> You can calculate the setting value as follows:
>
> $$Q_{>,thresh} = 100\ V \cdot 1\ A \cdot \sqrt{3} \cdot 0.05 = 8.7\ VA$$

Parameter: Operate delay

- Default setting (_:13921:6) Operate delay grid CB = 1.50 s
- Default setting (_:13921:108) Oper. delay generator CB = 0.50 s

You can set the Operate delay grid CB for the circuit breaker at the power-supply system connection point, or set the Oper. delay generator CB for the circuit breaker of the facility, for example, the generator.

The time of the Operate delay grid CB should always be set longer than the time of the Oper. delay generator CB.

Parameter: Trip interface contains

- Default setting (_:13921:101) Trip interface contains = operate (grid)

The stage provides 2 operate signals, the *Operate (generator)* and the *Operate (grid)*.

You use the Trip interface contains parameter to define whether one or none of them will be forwarded to the trip interface of the circuit-breaker interaction. The selected operate signal will trip the circuit breaker that has been connected to the protection function group.

The setting depends on the specific application.

Parameter: Q sign

- Default setting (_:13921:102) Q sign = not reversed

The default directions of the positive reactive-power flow Q and the forward direction of the short-circuit protection are identical, in the direction of the main protected object (for example, a feeder). You use the Q sign parameter to reverse the sign and therefore the direction of the reactive-power flow Q. This reversal may be required for specific application, where the main protected object (for example, a line towards the main power systems) is in different direction to the power-generation facility.

Parameter Value	Description
not reversed	The protected object is in the same direction as the power-generation facility.
reversed	The protected object is not in the same direction as the power generation facility.

6.37.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Prot. stage 1				
_:13921:1	Prot. stage 1:Mode		• off • on • test	off
_:13921:2	Prot. stage 1:Operate & flt.rec. blocked		• no • yes	no
_:13921:10	Prot. stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:13921:27	Prot. stage 1:Blk. w. inrush curr. detect.		• no • yes	no
_:13921:101	Prot. stage 1:Trip interface contains		• no operate • operate (generator) • operate (grid)	operate (grid)
_:13921:102	Prot. stage 1:Q sign		• not reversed • reversed	not reversed
_:13921:3	Prot. stage 1:Q> threshold value		1.00 % to 200.00 %	5.00 %
_:13921:103	Prot. stage 1:Vc threshold value		3.000 V to 175.000 V	85.000 V
_:13921:105	Prot. stage 1:I> release 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
_:13921:108	Prot. stage 1:Oper. delay generator CB		0.00 s to 60.00 s	0.50 s

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Addr.	Parameter	C	Setting Options	Default Setting
_:13921:6	Prot. stage 1:Operate delay grid T0		0.00 s to 60.00 s	1.20 s

6.37.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Prot. stage 1			
_:13921:81	Prot. stage 1:>Block stage	SPS	I
_:13921:54	Prot. stage 1:Inactive	SPS	O
_:13921:52	Prot. stage 1:Behavior	ENS	O
_:13921:53	Prot. stage 1:Health	ENS	O
_:13921:60	Prot. stage 1:Inrush blocks operate	ACT	O
_:13921:55	Prot. stage 1:Pickup	ACD	O
_:13921:301	Prot. stage 1:Op delay expir.(gen.)	ACT	O
_:13921:302	Prot. stage 1:Operate (generator)	ACT	O
_:13921:56	Prot. stage 1:Op.delay expir.(grid)	ACT	O
_:13921:57	Prot. stage 1:Operate (grid)	ACT	O

6.37.4 Description Reclosure Stage

6.37.4.1 Description

Logic of the Stage

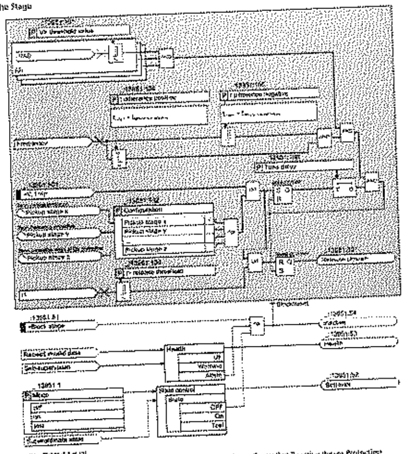

Figure 6-375 Logic Diagram of Reclosure Stage in Undervoltage-Controlled Reactive Power Protection

Measurand

The stage works with fundamental values of voltage and current.

Release for Reconnecting

The release for reconnecting the power-generation facility is given under the following conditions:

- All 3 phase-to-phase voltages are above the threshold value.
- The power frequency is within a specified range.
- The reclosure time delay, started by the operate of specific protection functions, has elapsed. The time delay is started by the first operate signal of the protection stages configured via the Configuration parameter. All protection stages of the voltage protection, the frequency protection, and the QV protection are available for configuration.

External Start of Reclosure Time Delay

Reclosure time delay can be started via the binary input signal >Ext. start, which can be connected to external voltage and frequency protection trip signals.

Blocking of the Stage

The stage can be blocked via the binary input signal >Block stage.

6.37.4.2 Application and Setting Notes

Parameter: Configuration

- Default setting (_:13951:102) Configuration = no stage

You use the Configuration parameter to define which operate signal of specific protection functions starts the release time delay of the Reclosure stage:

- Overfrequency protection
- Underfrequency protection
- Overvoltage protection
- Undervoltage protection
- Protection stage of undervoltage-controlled reactive-power protection

When the protection stage of undervoltage-controlled reactive-power protection is selected, only the signal Operate (generator) can start the release time delay of this stage. The signal Operate (grid) cannot start the release time delay.

The configuration depends on the specific application.

Parameter: I> release threshold

- Recommended setting value (_:13951:106) I> release threshold = 0.200 A

You use the I> release threshold parameter to define a precondition that the stage can work.

The default setting is at 10 % of the rated current. Siemens recommends using the default setting.

Parameter: V> threshold value

- Recommended setting value (_:13951:101) V> threshold value = 95.000 V

You use the V> threshold value parameter to set one of the 2 release criteria. The setting should be set above the lower value of the allowed voltage range, according to the national transmission code. In Germany, the recommended overvoltage threshold is 95 % of the rated voltage. Therefore Siemens recommends using the default setting.

Parameter: Frequency range

- Recommended setting value (_:13951:104) f difference positive = 0.05 Hz
- Recommended setting value (_:13951:105) f difference negative = -2.50 Hz

You use these 2 parameters to define the admitted frequency deviation from the rated frequency. f difference positive defines the upper frequency range limit. f difference negative defines the lower frequency range limit.

Siemens recommends using the default settings, which reflect common practice in Germany. Other national transmission codes may require a slightly different range.

Parameter: Time delay

- Default setting (_:13951:108) Time delay = 0.00 s

You use the Time delay parameter to specify the minimum time delay for releasing the reconnection of the power-generation facility after tripping by protection.

The setting depends on the specific application.

6.37.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Reclos. stage				
_:13951:1	Reclos. stage:Mode		• off • on • test	off
_:13951:101	Reclos. stage:V> threshold value		3.000 V to 340.000 V	95.000 V
_:13951:104	Reclos. stage:f difference positive		0.01 Hz to 5.00 Hz	0.05 Hz
_:13951:105	Reclos. stage:f difference negative		-5.00 Hz to -0.01 Hz	-2.50 Hz
_:13951:106	Reclos. stage:I> release threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.200 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
_:13951:108	Reclos. stage:Time delay		0.00 s to 3600.00 s	0.00 s
_:13951:102	Reclos. stage:Configuration		Setting options depend on configuration	

6.37.4.4 Information List

No.	Information	Data Class (Type)	Type
Reclos. stage			
_:13951:81	Reclos. stage:>Block stage	SPS	I
_:13951:501	Reclos. stage:>Ext. start	SPS	I
_:13951:54	Reclos. stage:Inactive	SPS	O
_:13951:52	Reclos. stage:Behavior	ENS	O
_:13951:53	Reclos. stage:Health	ENS	O
_:13951:301	Reclos. stage:Release closure	ACT	O

6.38 Fault Locator

6.38.1 Overview of Functions

The Fault locator function serves for measuring the fault distance in the event of a short circuit.

Quick determination of fault location and the associated rapid troubleshooting increase the availability of the line for the power transmission in the electrical power system. Determining the fault location is based on the loop-impedance calculation of short-circuited measuring loops.

6.38.2 Structure of the Function

The Fault locator function is used in the Line protection function group.

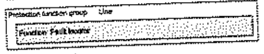

Figure 6-376 Structure/Embedding of the Function

The recording of phase currents and voltages is a prerequisite for calculation of fault locations. The Fault locator function contains all necessary control parameters.

Fault location calculation starts only if the functions Distance protection, Differential protection, Ground-fault protection or Overcurrent protection are picked up or triggered.

6.38.3 Function Description

Starting Conditions

The fault location is an independent function with its own measurand memory and its own filter algorithms. To define the valid measuring loop and the most favorable time interval for the measured variable saving, only a start command is required by the short-circuit protection. The fault location can be started by tripping of the short-circuit protection or also at each pickup. If another protection device causes the disconnection of a short-circuit, a fault-location calculation is then also possible for each pickup. In the event of a fault outside the line to be protected, the fault location indication cannot always be relevant, however, because the measurands can be falsified by the [illegible] infeed, for example.

Determining the Fault Location

The recorded sampled values of the short-circuit voltage and voltage are frozen shortly after tripping of the protection. No error in the measured value has then occurred through the switch-off process, even in the case of very fast circuit-breakers. The measurands and the impedance calculations are automatically filtered and may indicate a steady-state measured value in the determined data window.

After disconnection of the short-circuit, the measured values are analyzed and the fault location calculated from the short-circuit loops. If no fault location can be calculated, the indication Flt. Time [illegible] is output.

Output of the Fault Location

The following results for the fault location are output:

- Short circuit loop determined from the fault reactance
- Fault reactance X in Ω primary
- Fault resistance R in Ω primary
- Fault impedance in polar coordinates (amount in Ω, angle in degrees)

- Fault distance d of the line proportional to the reactance in kilometers or miles, converted on the basis of the parameterized reactance per unit length of the line
- Fault distance d as a percentage of the line length, calculated on the basis of the parameterized reactance per unit length and the parameterized line length
- Selected fault loop for calculation of the fault location

> **NOTE**
>
> Specification of distance in kilometers, miles, or percent is relevant only for homogeneous line sections. If the line comprises parts which exhibit different reactances per unit of length (for example, overhead-line cable sections), you can then analyze the reactance determined from the fault location for separate calculation of the fault distance.

Measured-Value Correction for Parallel Lines

In the event of ground faults on double lines, the values determined for the impedance calculation are influenced by the coupling of the ground impedances of both line systems. Without special measures, this leads to measuring errors in the impedance-calculation result. The device is therefore equipped with parallel-line compensation. This parallel-line compensation takes into account the ground current of the parallel line in the line equation and consequently compensates the coupling influence, similar to determining of the distance in distance protection. The ground current of the parallel line must be connected to the device and configured for this. The parallel-line compensation applies only to faults on the line to be protected. Compensation is not possible for faults located externally including those on the parallel line.

You can activate and deactivate the parallel-line compensation with the Parallel-line compensat. parameter.

Measured-Value Correction at Load Current on Lines Fed on Both Sides

In the case of faults on lines fed on both sides and with load transport (see next figure), the fault voltage V_{F1} is not only influenced by the source voltage E_1, but also by the source voltage E_2 if both voltage sources feed to the common fault resistance R_F. Without special measures, this leads to measuring errors in the impedance calculation result, since the current component I_2 cannot record at the measuring point M. For long lines and lines subject to high loads, this measuring error can be considerable in the crucial X component of the fault impedance (for the distance calculation).

The fault location has a load compensation, which corrects this measuring error in 1-pole short-circuits. A correction is not possible for the R component of the fault impedance. However, the measuring error is not critical here, as only the X component is decisive for the fault distance.

The load compensation acts in 1-phase short circuits. In doing so, both the positive-sequence and zero-sequence system of the balanced components are involved for the correction. You can activate and deactivate the load compensation via the Load compensation parameter.

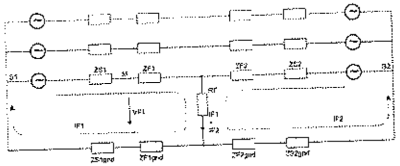

Figure 6-377 Fault Currents and Voltages in a Line Fed on Both Sides

M	Measuring point
S1, S2	Source voltage (EMF)
IF1, IF2	Partial fault currents
IF1 + IF2	Total fault current
VF1	Fault voltage at the measuring point
RF	Common fault resistance
ZF1, ZF2	Fault impedances
ZF1gnd, ZF2gnd	Ground fault impedances
ZS1, ZS2	External impedances
ZS1gnd, ZS2gnd	Ground external impedances

6.38.4 Application and Setting Notes

The function requires the following key line data to calculate fault distance:

- Reactance per unit length of the line per kilometer or per mile
- Line length for the correct output of the fault distance as a percentage of the line length
- Residual compensation adjustment factors in the setting format KR and KX or K0

NOTE

The visibility of the parameter Parallel-line compensat. depends on the selected setting format of the Line.
The parameter Parallel-line compensat. is visible if you have connected a parallel line for the device.

Parameter: Start

- Default setting (_:101) Start = with pickup

The Start parameter is used to define the criterion for starting the fault location.

Parameter Value	Description
with pickup	The calculation of a fault location occurs with dropout of the protection pickup.

Parameter Value	Description
with trip	The calculation of a fault location is started upon tripping of the protection function.

Parameter: Parallel-line compensation

- Default setting (_:102) Parallel-line compensat. = no

If you wish to apply the parallel-line compensation for double lines, set the Parallel-line compensat. parameter to yes.

Parameter Value	Description
no	The parallel-line compensation is deactivated with this setting.
yes	The parallel-line compensation becomes effective with this setting.

The following conditions have to be fulfilled so that the parallel-line compensation functions:

- Connect the ground current of the parallel line in the correct polarity to an additional current input.
- Set the input used for the parallel current in the current ratio to the phase currents for the power-system data.
- Set the coupling impedances to the parallel system for the line data.

Parameter: Load compensation

- Default setting (_:103) Load compensation = no

The Load compensation parameter can be used to correct measuring errors for 1-pole short circuits on lines fed on both sides. This is the case for overhead lines without grounding cable or with unfavorable grounding conditions of the towers, if high transition resistances can occur in the event of 1-pole short circuits.

Parameter Value	Description
no	The load compensation is deactivated with this setting.
yes	The load compensation becomes effective with this setting.

6.38.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Fault locator				
_:1	Fault locator:Mode		• off • on • test	off
_:101	Fault locator:Start		• with operate • with going pickup	with going pickup
_:102	Fault locator:Parallel-line compensat.		• no • yes	yes
_:103	Fault locator:Load compensation		• no • yes	no

6.38.6 Information List

No.	Information	Data Class (Type)	Type
Fault locator			
_:54	Fault locator:Inactive	SPS	O

No.	Information	Data Class (Type)	Type
_:52	Fault locator:Behavior	ENS	O
_:53	Fault locator:Health	ENS	O
_:302	Fault locator:Fault resistance prim.	MV	O
_:304	Fault locator:Fault reactance prim.	MV	O
_:308	Fault locator:Fault resistance sec.	MV	O
_:309	Fault locator:Fault reactance sec.	MV	O
_:305	Fault locator:Fault distance	MV	O
_:307	Fault locator:Fault distance in %	MV	O
_:306	Fault locator:Fault loop	ENS	O
_:301	Fault locator:FL invalid	SPS	O

6.39 Overfrequency Protection

6.39.1 Overview of Functions

The **Overfrequency protection** function (ANSI 81O):

- Detect overfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Disconnect generating units when the power frequency is critical
- Provide additional turbine protection if the speed limiter fails

Frequency deviations are caused by an unbalance between the active power generated and consumed. Overfrequency is caused by load shedding (island network), power system disconnection or disturbances of the frequency controller. Overfrequency implies a risk of self-excitation of machines which are connected to long lines without load.

Overfrequency protection is available in two functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

6.39.2 Structure of the Function

The **Overfrequency protection** function is used in protection function groups, which are based on voltage measurement.

The overfrequency protection function comes with 2 factory-set stages. A maximum of 3 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters Dropout differential and Minimum voltage are set for all stages.

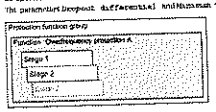

Figure 6-378 Structure/Embedding of the Function

6.39.3 Overfrequency-Protection Stage

Logic of a Stage

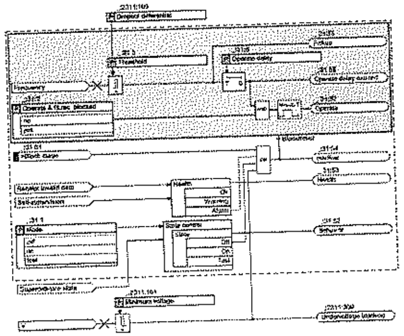

Figure 6-379 Logic Diagram of the Overfrequency Protection Stage

Frequency-Measurement Method

Overfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency measurement method in dependence of the application.

- Angle-difference method (method A):
  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.
- Filtering method (method B):
  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage.

Both methods of measurement are characterized by a high measuring accuracy combined with a short pickup time. Disturbance values such as harmonics, high frequency disturbances, phase-angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.

Functional Measured Value

The angle-difference method provides the following measured value.

Value	Description
f	Calculated frequency with the angle-difference method

Behavior on Leaving the Operating Range

The sampling frequency tracking makes an additional frequency-operating range possible. If the stage has picked up before leaving the frequency-operating range and the measuring voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

Blocking will cause a tripping stage that has picked up to dropout. The following blocking options are available for the stage:

- Externally or internally via the logical binary input >Block stage
- Internally when the voltage drops below the Minimum voltage

6.39.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.
Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a 2-out-of-2 decision by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Frequency-Measurement Method	Description
Angle difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value (_:3) Threshold = 51.50 Hz for f_{rated} = 50 Hz

The Threshold parameter is used to define the pickup threshold of the overfrequency protection stage in dependence of the application. 51.50 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 10 s

The Operate delay parameter is used to set the stage so that malfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value (_:2311:101) Minimum voltage = 37.5 V

For the Undervoltage blocking 65 % of the protected object's rated voltage is recommended.

When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value (_:2311:109) Dropout differential = 20 mHz

Due to the high-precision frequency measurement, the recommended setting value for the Dropout differential can remain at 20 mHz. For a later dropout of the stage, increase the setting value of the dropout differential. For example, if the pickup value (parameter Threshold) of the stage is set at 51.5 Hz and the Dropout differential to 100 mHz, the stage will drop out at 51.4 Hz.

Setting example of the overfrequency protection for generators

If the overspeed limiter does not function properly, the overfrequency protection provides an additional stage. Overfrequency can be caused by load shedding or by a disturbance of the speed limiter (for example, in an island network).

One possible frequency limit could be 1.03 f_{rated}. If the machine does not recover, it can be shut down with a 2nd stage at, for example, 1.08 f_{rated}. To avoid malfunctions, you can set a sufficient time delay for the warning indication or tripping.

For this application, 2 stages of the overfrequency protection are used. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1>	Warning or disconnection	51.50 Hz	61.80 Hz	20.00 s
f2>	Shutdown	54.00 Hz	64.80 Hz	5.00 s

> **NOTE**
> This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

6.39.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:91:1	Stage 1:Mode		• off • on • test	off
_:91:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:91:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	51.50 Hz
_:91:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:92:1	Stage 2:Mode		• off • on • test	off
_:92:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:92:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	54.00 Hz
_:92:6	Stage 2:Operate delay		0.00 s to 600.00 s	5.00 s

6.39.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:Undervoltage blocking	SPS	O
_:2311:301	General:Inactive	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:91:81	Stage 1:>Block stage	SPS	I
_:91:54	Stage 1:Inactive	SPS	O
_:91:52	Stage 1:Behavior	ENS	O
_:91:53	Stage 1:Health	ENS	O
_:91:55	Stage 1:Pickup	ACD	O
_:91:56	Stage 1:Operate delay expired	ACT	O
_:91:57	Stage 1:Operate	ACT	O
Stage 2			
_:92:81	Stage 2:>Block stage	SPS	I
_:92:54	Stage 2:Inactive	SPS	O
_:92:52	Stage 2:Behavior	ENS	O
_:92:53	Stage 2:Health	ENS	O
_:92:55	Stage 2:Pickup	ACD	O
_:92:56	Stage 2:Operate delay expired	ACT	O
_:92:57	Stage 2:Operate	ACT	O

6.40 Underfrequency Protection

6.40.1 Overview of Functions

The Underfrequency protection function (ANSI 81U) is used to:

- Detect underfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Decouple power systems
- Load shedding to ensure power system stability and protect motors
- Disconnect generating units when the power system frequency is critical (for example, < 0.95 f_{rated})

Frequency deviations are caused by an unbalance between the active power generated and consumed. Underfrequency is caused by an increase of the consumers' active power demand or by a decrease of the power generated. These conditions occur in the case of power system disconnection, generator failure, or disturbances of the power and frequency controller.

Underfrequency protection is available in 2 functional configurations (selectable from the DIGSI functions library). The functional configurations differ in the frequency measurement method they use.

6.40.2 Structure of the Function

The Underfrequency protection function is used in protection function groups, which are based on voltage measurement.

The Underfrequency protection function comes with 2 factory-set stages. A maximum of 5 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters Dropout differential and Minimum voltage are set for all stages.

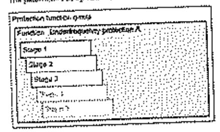

Figure 6-380 Structure/Embedding of the Function

6.40.3 Underfrequency-Protection Stage

Logic of a Stage

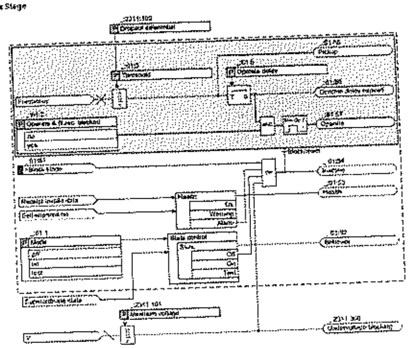

Figure 6-381 Logic Diagram of the Underfrequency-Protection Stage

Frequency-Measurement Method

Underfrequency protection is available in 2 functional configurations. These work with different frequency-measurement methods. You select the frequency measurement method in dependence of the application.

- Angle-difference method (method A):
  The angle-difference method determines the phasor of the positive-sequence voltage in multiphase systems. In the case of 1-phase connection, it always processes the phasor of the connected voltage. Since the change of angle of the voltage phasor over a given time interval is proportional to the frequency change, the current frequency can be derived from it.
- Filtering method (method B)
  The filtering method processes the instantaneous voltage values and determines the current frequency using a suitable combination of filters. The frequency-protection function selects automatically the largest voltage as the measurand. In a multiphase connection, the phase-to-phase voltage is always the largest. If in a multiphase connection the selected voltage is no longer available, the function changes over automatically to the next maximum voltage. The function can even operate with just one voltage.

Both methods of measurement are characterized by a high measuring accuracy combined with a short response time. Disturbance values such as harmonics, high frequency disturbances, phase angle jumps during switching operations and compensation processes due to power swings are effectively suppressed.

Behavior on Leaving the Operating Range

The sampling frequency tracking makes an additional frequency-operating range possible. If the stage has picked up before leaving the frequency-operating range and the measured voltage is higher than the set minimum voltage, the pickup is maintained. A dropout of the pickup is only possible by means of a blocking.

Blocking the Stage

Blocking will cause a tripping stage that has picked up to dropout. The following blocking options are available for the stage:

- Via the binary input signal >Block stage from an external or internal source
- Internally when the voltage drops below the Minimum voltage

6.40.4 Application and Setting Notes

Frequency-Measurement Method

The frequency-measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a 2-out-of-2 decision by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Method of Measurement	Description
Angle-difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value (_:61:3) Threshold = 49.80 Hz for f_{rated} = 50 Hz

The Threshold parameter is used to define the pickup threshold of the underfrequency protection stage in dependence of the application. 49.8 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value (_:61:6) Operate delay = 10.00 s

The Operate delay parameter is used to set the stage so that malfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value (_:2311:101) Minimum voltage = 37.500 V

For the Undervoltage blocking, 65 % of the protected object's rated voltage is recommended.

When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value (_:2311:109) Dropout differential = 20 mHz

Due to the high-precision frequency measurement, the recommended setting value for the Dropout differential can remain at 20 mHz. If in your application you wish a subsequent dropout of the tripping stage, then increase the setting value of the dropout differential. For instance, if the pickup value (parameter Threshold) of the tripping stage is set to 49.8 Hz and the Dropout differential to 100 mHz, the stage will drop out at 49.9 Hz.

Setting example of the underfrequency protection for generators

The underfrequency protection provides an additional protection for the turbine. It has the task of ensuring the [illegible] of the power plant system by a timely decoupling from the electrical power system. After the decoupling from the electrical power system, the turbine set continues with the generator unit at the rated speed, so that the demand can continue to be supplied with rated frequency.

Turbogenerators can operate permanently at as little as 95 % of the rated frequency. This requires the apparent power to be reduced by the same factor. A decrease of the frequency leads not only to a higher current consumption by the inductive loads but is also a hazard to stable operation.

The decoupling from the electrical power system is initiated without delay at 0.95 f_{rated}. After the decoupling, the generating unit has to recover. If it does not, the turbine is stopped for its own protection. In the turbine, underfrequency can lead to resonances and inadmissible strains of the turbine blades. You can delay the trip [illegible] in order to give the speed controllers sufficient time for a response.

The frequency value to be set depends on the specifications of the power plant operator or the turbine manufacturer (speed monitoring). It is approx. 0.94 f_{rated}.

For this application, 3 stages of the underfrequency protection are used. The following table shows a setting suggestion.

Stage	Caused by	Setting Values		
		At f_{rated} = 50 Hz	At f_{rated} = 60 Hz	Delay
f1<	Warning	49.80 Hz	59.80 Hz	10.00
f2<	Decoupling from power system	47.50 Hz	57.00 Hz	0.00
f3<	Shutdown	47.00 Hz	56.40 Hz	10.00

> **NOTE**
> This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application and the turbine.

6.40.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:61:1	Stage 1:Mode		• off • on • test	off
_:61:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:61:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	49.50 Hz
_:61:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:62:1	Stage 2:Mode		• off • on • test	off

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Addr.	Parameter	C	Setting Options	Default Setting
_:62:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:62:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	47.50 Hz
_:62:6	Stage 2:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 3				
_:63:1	Stage 3:Mode		• off • on • test	off
_:63:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:63:3	Stage 3:Threshold		40.00 Hz to 70.00 Hz	47.00 Hz
_:63:6	Stage 3:Operate delay		0.00 s to 600.00 s	50.00 s

6.40.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:302	General:Undervoltage blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:61:81	Stage 1:>Block stage	SPS	I
_:61:54	Stage 1:Inactive	SPS	O
_:61:52	Stage 1:Behavior	ENS	O
_:61:53	Stage 1:Health	ENS	O
_:61:55	Stage 1:Pickup	ACD	O
_:61:56	Stage 1:Operate delay expired	ACT	O
_:61:57	Stage 1:Operate	ACT	O
Stage 2			
_:62:81	Stage 2:>Block stage	SPS	I
_:62:54	Stage 2:Inactive	SPS	O
_:62:52	Stage 2:Behavior	ENS	O
_:62:53	Stage 2:Health	ENS	O
_:62:55	Stage 2:Pickup	ACD	O
_:62:56	Stage 2:Operate delay expired	ACT	O
_:62:57	Stage 2:Operate	ACT	O
Stage 3			
_:63:81	Stage 3:>Block stage	SPS	I
_:63:54	Stage 3:Inactive	SPS	O
_:63:52	Stage 3:Behavior	ENS	O
_:63:53	Stage 3:Health	ENS	O
_:63:55	Stage 3:Pickup	ACD	O
_:63:56	Stage 3:Operate delay expired	ACT	O
_:63:57	Stage 3:Operate	ACT	O

6.41 Rate of Frequency Change Protection

6.41.1 Overview of Functions

The function Rate of frequency change protection is used to:

- Detect a frequency change quickly
- Prevent the system from unsecure states caused by unbalance between the generated and consumed active power
- Network decoupling
- Load shedding

6.41.2 Structure of the Function

The function Rate of frequency change protection can be used in protection function groups containing 3-phase voltage measurement.

2 function block types are available:

- df/dt rising
- df/dt falling

The function **Rate of frequency change protection** is preconfigured by the manufacturer with 1 df/dt rising stage and 1 df/dt falling stage. A maximum of 5 df/dt rising stages and 5 df/dt falling stages can operate simultaneously within the function. Both of the function block types are similar in structure.

Undervoltage check and df/dt calculation are general functionalities and take place on the function level. All stages use these general functionalities.

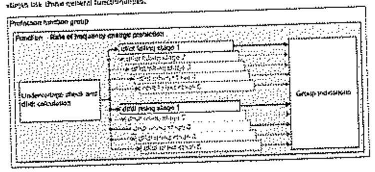

Figure 6-382 Structure/Embedding of the Function

6.41.3 General Functions (Undervoltage Test, df/dt Calculation)

6.41.3.1 Description

Logic

The following figure represents the logic of undervoltage check and df/dt calculation. It applies to all types of stages.

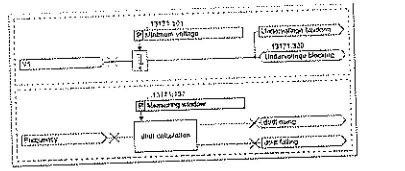

Figure 6-383 Logic Diagram of General Functionality

Measurand

This function uses the frequency calculated via the angle difference algorithm.

For more information, refer to chapter 6.39.3 Overfrequency Protection Stage .

The frequency difference is calculated over a settable time interval (default setting, 5 periods).

The ratio between the frequency difference and the time difference reflects the frequency change which can be positive or negative.

A stabilization counter works to avoid overfunction. This counter is increased if the set threshold value is exceeded. If the value drops below the threshold value, the counter is reset immediately. The counter is set to 8 internally and is activated at each half system cycle.

Undervoltage Blocking

If the measuring voltage drops below the Minimum voltage, the Rate of frequency change protection is blocked because precise frequency values cannot be calculated anymore.

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

6.41.3.2 Application and Setting Notes

Parameter: Minimum voltage

- Recommended setting value (_:13171:101) Minimum voltage = 37,500 V

For the Undervoltage blocking, 65 % of the rated voltage of the protected object is recommended. The method of measurement uses the phasor of the positive-sequence voltage. When determining the setting value, keep in mind that the absolute value of the scaled positive-sequence voltage is equal to the absolute value of the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Measuring window

- Default setting (_:13171:137) Measuring window = 5 periods

You can use the Measuring window parameter to optimize the measuring accuracy or the pickup time of the function. For information regarding pickup time and measuring accuracy, refer to the technical data. The default setting provides maximum measuring accuracy. If you do not have specific requirements for a decreased pickup time, Siemens recommends using the default setting.

The default setting is a reasonable compromise between measuring accuracy and pickup time. For a more sensitive setting (high threshold value), you can set the parameter Measuring window to a smaller value.

6.41.4 Stage Description

6.41.4.1 Description

Logic of the Stage

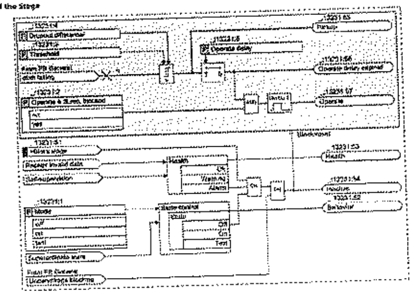

Figure 6-384 Logic Diagram of Rate of Frequency Change Protection

(1) For the stage type df/dt rising, the value df/dt rising is used.

Frequency Rising/Falling

The stage df/dt falling is used to detect frequency falling and the stage df/dt rising is used to detect frequency rising.

You set the threshold value as an absolute value. You define the frequency change direction via the selected stage type.

Blocking of the Stage

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage
- Via the undervoltage blocking when the voltage drops below the Minimum voltage

6.41.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting (_:13231:3) Threshold = 3.0 Hz/s

The pickup value depends on the application and is determined by power-system conditions. In most cases, a network analysis will be necessary. A sudden disconnection of loads leads to a surplus of active power. The frequency rises and causes a positive frequency change. On the other hand, a failure of generators leads to a deficit of active power. The frequency drops and results in a negative frequency change.

The following relations can be used as an example for estimation. They apply for the change rate at the beginning of a frequency change (approximate 1 s).

$$\frac{df}{dt} = -\frac{f_{rated}}{2H} \cdot \frac{\Delta P}{S_{rated}}$$

Where:

f_{rated}	Rated frequency
ΔP	Active power change $\Delta P = P_{Consumption} - P_{Generation}$
S_{rated}	Rated apparent power of the machines
H	Inertia constant

Typical data for H:

For hydro generators (salient-pole machines)	H = 1.5 s to 6 s
For turbine-driven generators (non-salient pole rotors)	H = 2 s to 10 s
For industrial turbine-driven generators	H = 3 s to 4 s

EXAMPLE

f_{rated} = 50 Hz

H = 3 s

Case 1: $\Delta P/S_{rated}$ = 0.12

Case 2: $\Delta P/S_{rated}$ = 0.48

Case 1: df/dt = -1 Hz/s

Case 2: df/dt = -4 Hz/s

Parameter: Operate delay

- Default setting (_:13231:6) Operate delay = 1.00 s

You can use the Operate delay parameter to avoid overfunction due to disturbing influences (for example, switching operations). If the protection function is supposed to respond quickly, set the Operate delay parameter to 0 s.

For monitoring small changes (< 1 Hz/s), a small time delay is useful to avoid overfunctioning.

Parameter: Dropout differential

- Recommended setting value (_:13231:4) Dropout differential = 0.10 Hz/s

You can use the Dropout differential parameter to define the dropout value. The recommended value is 0.10 Hz/s.

NOTE

In case of power-system incidents, especially in case of transmission incidents and influence of voltage-stabilizing measures via power-electronic components (reactive-power compensation through SVC), the amplitude and the phase angle of the voltage can change. Sensitive settings can lead to overfunction. Therefore, it is reasonable to block the **Rate of Frequency Change Protection** if other protection functions, for example, residual voltage or negative sequence voltage, pick up. To do this, use the blocking input >Block stage and connect it via CFC.

6.41.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13171:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:13171:137	General:Measuring window		2 periods to 5 periods	5 periods
df/dt falling1				
_:13231:1	df/dt falling1:Mode		• off • on • test	off
_:13231:2	df/dt falling1:Operate & flt.rec. blocked		• no • yes	no
_:13231:3	df/dt falling1:Threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:13231:4	df/dt falling1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13231:6	df/dt falling1:Operate delay		0.00 s to 60.00 s	1.00 s
df/dt rising1				
_:13201:1	df/dt rising1:Mode		• off • on • test	off
_:13201:2	df/dt rising1:Operate & flt.rec. blocked		• no • yes	no
_:13201:3	df/dt rising1:Threshold		0.1 Hz/s to 20.0 Hz/s	3.0 Hz/s
_:13201:4	df/dt rising1:Dropout differential		0.02 Hz/s to 0.99 Hz/s	0.10 Hz/s
_:13201:6	df/dt rising1:Operate delay		0.00 s to 60.00 s	1.00 s

6.41.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:13171:300	General:Undervoltage blocking	SPS	O
_:13171:301	General:df/dt	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
df/dt falling1			
_:13231:81	df/dt falling1:>Block stage	SPS	I
_:13231:54	df/dt falling1:Inactive	SPS	O
_:13231:52	df/dt falling1:Behavior	ENS	O
_:13231:53	df/dt falling1:Health	ENS	O
_:13231:55	df/dt falling1:Pickup	ACD	O

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No.	Information	Data Class (Type)	Type
_:13201:56	df/dt falling1:Operate delay expired	ACT	O
_:13201:57	df/dt falling1:Operate	ACT	O
df/dt rising 1			
_:13201:81	df/dt rising1:>Block stage	SPS	I
_:13201:54	df/dt rising1:Inactive	SPS	O
_:13201:52	df/dt rising1:Behavior	ENS	O
_:13201:53	df/dt rising1:Health	ENS	O
_:13201:55	df/dt rising1:Pickup	ACD	O
_:13201:56	df/dt rising1:Operate delay expired	ACT	O
_:13201:57	df/dt rising1:Operate	ACT	O

6.42 Phase-Rotation Reversal

6.42.1 Overview of Functions

The Phase-sequence switchover function enables correct execution of the protection of the device and supervision functions, independently of the phase sequence in a system or system section. The phase sequence is set via parameter. You can select between the phase sequences ABC or ACB. Binary inputs provide the option of switching over the phase sequence contrary to the parameter setting. By changing over the phase sequence you temporarily change the direction of rotation in motors for example. The phase sequence has an effect on calculation of the positive-sequence system and negative-sequence system values and on calculation of phase to phase values. A phase-rotation reversal therefore has an effect on all protection and supervision functions that use these values.

You can change the phase sequence in 2 ways via binary inputs:

- Change over the phase sequence for the entire device. In doing so, all 3-phase measuring points are switched over. All analog inputs are therefore affected (for example, current and voltage inputs simultaneously).
- Changing over the phase sequence per measuring point. In doing so, only the activated measuring points are switched over. The other measuring points remain unaffected.

6.42.2 Structure of the Function

The Phase-sequence switchover function is integrated in the Power-system data. You will find the signals in the DIGSI 5 project tree under Name of the device → Parameters. There you will find the parameter for setting the phase sequence and the binary inputs via which you can influence a change in the phase sequence.

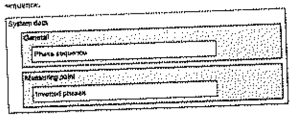

Figure 6-385 Structure/Embedding of the Function

6.42.3 Function Description

General

The phase sequence of the system is set in the device via the Phase sequence parameter. You will find the signals in the DIGSI 5 project tree under Name of the device → Parameters → Power-system data → General. There are 2 methods to change the phase sequence for different operational requirements.

- With the binary signal >Phs-rotation reversal you change over the phase sequence of all measuring points.
- With the binary signal >Invert Phases you change over the phase sequence per measuring point. The Inverted phases parameter available per measuring point is used to set which phases at the measuring point must be swapped. The parameter can be found at each 3-phase measuring point.

The two mechanisms are explained separately below.

Switchover of the Phase Sequence at All Measuring Points

The direction of rotation of the currents and voltages depends on the phase sequence. The following drawing shows the vector definitions for the 2 phase sequences.

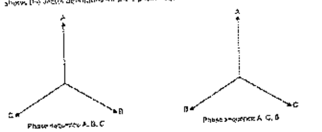

Figure 6-386 Vector with Different Phase Sequences

The phase sequence of a system or a system section is defined when parameterizing via the Phase sequence parameter. The setting parameter acts on all measuring points. The operationally induced switchover between the phase sequence ABC and the phase sequence ACB is initiated via the binary input >Invert Phases. This switches over the phase sequence simultaneously at all 3-phase measuring points.

The following image shows a logic diagram for determining the current phase assignment and switchover. The indications shown on the right show the present phase sequence. If the phase sequence is set via the Phase sequence parameter to ABC, the activation of the binary input will result in a switchover to the phase sequence ACB.

The switchover of the phase sequence is only authorized for a time at which no measured values are pending. The switchover command must be present for at least 200 ms. The change of phase sequence is only permissible when the machine is at standstill. If the current and voltage values of all 3-phase measuring points are below 5 % of the nominal variable, this is recognized as machine standstill.

A renewed machine standstill must be detected for a resetting of the phase sequence to the set preferred position.

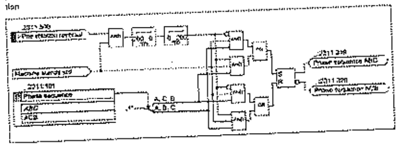

Figure 6-387 Phase Sequence Switchover

Changing Over the Phase Sequence per Measuring Point

A switchover of the phase sequence per measuring point can also be necessary for operational reasons. This switchover enables proper performance of the protection devices at the transition from generator operation to motor operation (pump operation).

The following example shows an application in a pumped storage plant. The switchover of the phase sequence (change in rotational direction) realizes the transition there from generator operation to motor operation. Which phases and measuring points are changed over depends on the conditions in the system.

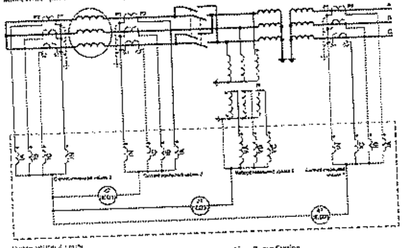

Figure 6-388 Application Example for Phase Rotation Reversal in a Pump Station

The example shows 2 differential protection devices (IED1 and IED2) and an impedance protection (IED3) with the connected measuring points.

The phase sequence is insignificant for the differential protection of IED1, as the protected object is not affected by the switchover option of the phase sequence.

The phase sequence is also relevant to the differential protection of IED2, as the protected object extends beyond the switchover option.

The phase sequence is also relevant to the impedance protection (IED3). Depending on the switch position, the voltage measured values 1 and the current measured values 3 have a different phase sequence.

The phase sequence of the system is set in the device via the Phase sequence parameter for generator operation. The Inverted phases parameter is used to set which phase is swapped for the relevant measuring point. The swap is communicated to the measuring point via the binary input signal >Invert Phases. The changed phase sequence is then included for calculation of the measurands of the measuring point.

In accordance with Figure 6-388, the phase sequence is set to ABC. A is swapped with C in motor operation. The Inverted phases parameter must be set to AC for the current measured values 2 and current measured values 3 measuring points. As a result, the phase assignment for the differential protection IED2 and the impedance protection IED3 is correct. The positive sequence and negative-sequence current is calculated correctly.

The following logic diagram shows the principle for determining the present phase assignment and measured variables with the example of currents.

The switchover of the phase sequence is only authorized for a time at which no measured values are pending. The switchover command must be present for at least 200 ms. The change of phase sequence is only permissible when the machine is at standstill. In doing so, the system checks for the measuring point to be switched over whether the measured variables are below 5 % of the nominal variables. If the currents at the measuring points current measured values 2 and current measured values 3 in the example fall below 5 % of their nominal variables, machine standstill is detected.

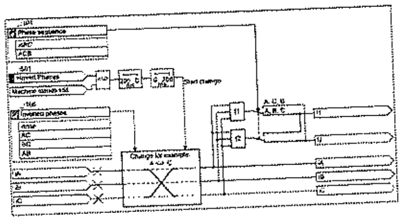

Figure 6-389 Measured Values for Changed Over Phases

6.42.4 Application and Setting Notes

Parameter: Phase sequence

- Default setting (_:101) Phase sequence = ABC

ABC	Phase sequence A, B, C
ACB	Phase sequence A, C, B

Parameter: Inverted phases

- Default setting (_:106) Inverted phases = none

none	No phase exchange
AC	Phase A changed over with phase C
BC	Phase B changed over with phase C
AB	Phase A changed over with phase B

Input signal: >Phs-rotation reversal

The binary input >Phs-rotation reversal is used to switch over between the phase sequence ABC and the phase sequence ACB. The switchover direction depends on the setting of the Phase sequence parameter. In doing so, the phase sequence of all 3-phase measuring points is changed.

Input signal: >Invert Phases

The binary input >Invert Phases is used to activate the setting of the parameter Inverted phases. In doing so, the phase sequence of the selected measuring point is changed.

6.42.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	General:Phase sequence		• ABC • ACB	ABC
General				
_:101	VT 3-phase:Rated primary voltage		0.20 kV to 1200.00 kV	400.00 kV
_:102	VT 3-phase:Rated secondary voltage		80 V to 230 V	100 V
_:103	VT 3-phase:Matching ratio Vph / VN		0.10 to 9.99	1.73
_:104	VT 3-phase:VT connection		• 3 ph-to-gnd volt. + VN • 3 ph-to-gnd voltages • 3 ph-to-ph volt. + VN • 3 ph-to-ph voltages	3 ph-to-gnd volt. + VN
_:106	VT 3-phase:Inverted phases		• none • AC • BC • AB	none
_:111	VT 3-phase:Tracking		• inactive • active	active
_:107	VT 3-phase:Measuring-point ID		0 to 100	0

6.42.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:500	General:>Phs-rotation reversal	SPS	I
_:501	General:>Invert Phases	SPS	I
General			
_:319	General:Phase sequence ABC	SPS	O
_:320	General:Phase sequence ACB	SPS	O
_:321	General:Freq.out of oper.range	SPS	O
_:322	General:f sys	MV	O
_:323	General:f track	MV	O
General			
_:315	VT 3-phase:Phases AB inverted	SPS	O
_:316	VT 3-phase:Phases BC inverted	SPS	O
_:317	VT 3-phase:Phases AC inverted	SPS	O

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6.43 Instantaneous Tripping at Switch onto Fault

6.43.1 Overview of Functions

The Instantaneous tripping at switch onto fault function serves for immediate tripping when switching onto a fault.
The function does not have its own measurement and must be linked to another protection function with the pickup (measurement).

6.43.2 Structure of the Function

The function Instantaneous tripping at switch onto fault can be used in all protection function groups. The function is preconfigured with a stage. A maximum of 2 tripping stages can be operated simultaneously in the function. The stages have an identical structure.

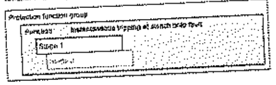


Figure 6-390 Structure/Embedding of the Function

6.43.3 Stage Description

Logic of the Stage

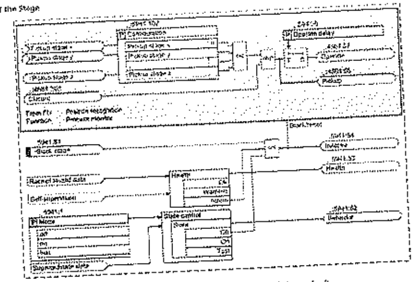


Figure 6-391 Logic Diagram of the Stage Instantaneous Tripping in Switch onto Fault

Connection of the Stage

The stage is intended to initiate instantaneous tripping when switching onto a fault. To do this, the stage must be connected to one or more pickups from protection functions or protection stages, for example, to pickup of an overcurrent protection stage. That is, the stage of the Instantaneous tripping at switch onto fault function does not have its own measuring function but requires the pickup of another protection function or protection stage to pick up.
The stage is active only if switching is pending or executed (for this, see section 6.14 Overcurrent Protection, Phases).

> **NOTE**
>
> If the pickup of a protection stage takes place and tripping is blocked by the inrush-current detection function, on pickup of the Instantaneous tripping at switch onto fault function takes place. In this case, there is no fault recording neither. Despite this, if a fault recording is necessary, you can activate it with the parameter (_:114) Start flt.rec. of the Inrush-current detection function (see chapter 6.51 Inrush-Current Detection).

6.43.4 Application and Setting Notes

Parameter: Configuration

- Default setting (_:5941:102) Configuration = no stage

The Configuration parameter is used to define with which pickup of a protection function or protection stage the Instantaneous tripping at switch onto fault function responds.
Normally, the pickups of protection functions and stages with high fault current are selected:

- Overcurrent protection (phase and ground)
- Directional time overcurrent protection (phase and ground)
- Ground-fault protection for grounded systems

A specific protection stage is generally used. This can be one of the protection stages provided for the protection application, which itself trips with a delay. An additional protection stage with settings optimized for this use case, for example, increased threshold value and blocking of self-tripping, can also be used.

Parameter: Operate delay

- Recommended setting value (_:5941:6) Operate delay = 0.00 s

When switching onto a fault, the tripping should usually be instantaneous. The tripping delay is therefore set to 0.

6.43.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:5941:1	Stage 1:Mode		• off • on • test	off
_:5941:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:5941:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.00 s
_:5941:102	Stage 1:Configuration		Setting options depend on configuration	

6.43.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:5941:81	Stage 1:>Block stage	SPS	I
_:5941:54	Stage 1:Inactive	SPS	O
_:5941:52	Stage 1:Behavior	ENS	O
_:5941:53	Stage 1:Health	ENS	O
_:5941:55	Stage 1:Pickup	ACD	O
_:5941:57	Stage 1:Operate	ACT	O

6.44 Thermal Overload Protection, 3-Phase

6.44.1 Overview of Functions

The Thermal overload protection function (ANSI 49) is used to:

- Protect the equipment (motors, generators, transformers, capacitors, overhead lines, and cables) against thermal overloads
- Monitor the thermal state of motors, generators, transformers, capacitors, overhead lines, and cables

6.44.2 Structure of the Function

The Thermal overload protection, 3-phase function is used in protection function groups with current measurement.
The function is preconfigured by the manufacturer with 1 Thermal overload protection stage.
The non-preconfigured function block Filter can optionally be applied to gain the RMS value used by the Thermal overload protection stage.

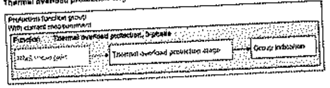


Figure 6-392 Structure/Embedding of the Function

6.44.3 Filter for RMS Value Gain

6.44.3.1 Description

The function block Filter can be used to adapt the RMS value for 2 reasons:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter.
- To only compensate the amplitude attenuation of higher frequencies by the device (due to the anti-aliasing filter).

The filter gain (amplitude response) is realized by a 9th order FIR filter.

Logic

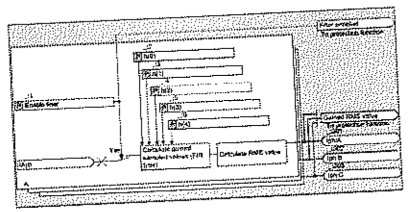


Figure 6-393 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the respective parameters h(0), h(1), h(2), h(3) and h(4).

> **NOTE**
>
> A FIR-filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block Filter is instantiated and the parameter Enable filter is set to yes. Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Filtered RMS measured value of current A	kA	A	Parameter Rated current
Iph:B	Filtered RMS measured value of current B	kA	A	Parameter Rated current
Iph:C	Filtered RMS measured value of current C	kA	A	Parameter Rated current

You can find the parameter Rated current in the FB General of function groups where the Thermal overload protection function is used.
If the parameter Enable filter is set to no, the function values are shown as ---.

6.44.3.2 Application and Setting Notes

Parameter: Enable filter

- Default setting (_:1) Enable filter = no

With the parameter Enable filter, you set whether the Filter is enabled.

Parameter Value	Description
yes	If gained RMS values should be used in one of the protection stages, set parameter Enable filter = yes.
no	If no gained RMS values are needed, set the parameter Enable filter = no.

Parameter: h(0), h(1), h(2), h(3), h(4)

- Default setting (_:2) h(0) = 0.000
- Default setting (_:3) h(1) = 0.000
- Default setting (_:4) h(2) = 0.000
- Default setting (_:5) h(3) = 0.000
- Default setting (_:6) h(4) = 1.000

With the default value of the coefficients, the filter has no effect and no gain is applied.
If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically taken into account and compensated by the filter.
To only compensate the attenuation of higher frequencies by the device, set the following coefficients in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.040 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.1??

6.44.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filter				
_:1	Filter:Enable filter		• no • yes	no
_:2	Filter:h(0)		-100.000 to 100.000	0.000
_:3	Filter:h(1)		-100.000 to 100.000	0.000
_:4	Filter:h(2)		-100.000 to 100.000	0.000
_:5	Filter:h(3)		-100.000 to 100.000	0.000
_:6	Filter:h(4)		-100.000 to 100.000	1.000

6.44.3.4 Information List

No.	Information	Data Class (Type)	Type
PT1 cnt		MV	O
_:301	Fiber:phsA	MV	O
_:302	Fiber:phsB	MV	O
_:303	Fiber:phsC		

6.45 Thermal Overload Protection, 1-Phase

6.45.1 Overview of Functions

The Thermal overload protection 1-phase function (ANSI 49) is used to:

- Protect the equipment (reactors or resistors at the neutral point of a transformer) from thermal overload

6.45.2 Structure of the Function

The Thermal overload protection 1-phase function is used in 1-phase protection function groups with current measurement.

The Thermal overload protection, 1-phase function is completely preconfigured.

Protection function group 1-phase with current measurement
Function Thermal overload protection 1-ph.

Figure 6-394 Structure/Embedding of the Function

6.45.3 Function Description

Logic

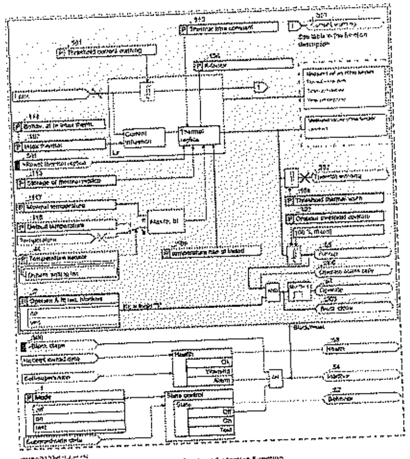


Figure 6-395 Logic Diagram of the Thermal Overload Protection Function

Thermal Replica

The protection function calculates the overtemperature from the current flowing in the protected object (for example, reactor or resistance in the transformer neutral point) on the basis of a thermal single-body model according to the thermal differential equation with

$$\dot{\Theta}_{th} = \tau_{th}\frac{d\Theta}{dt} + \Theta - \Theta_{u}$$

With the following standardization:

[illegible]

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible current $k \cdot I_{rated,obj}$
$Θ_u$	Standardized ambient temperature, where $ϑ_{amb}$ describes the coupled ambient temperature. The coupled ambient temperature $ϑ_{amb}$ can be the measured ambient temperature or the ambient temperature preset using the Default temperature parameter.
$Δϑ_{rated,obj}$	Overtemperature of the protected object set at rated current
$τ_{th}$	Thermal time constant (temperature rise/cooling) of the protected object
k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated,obj}$)
$I_{rated,obj}$	Rated current of the protected object

At the same time, $I_{rated,obj}$ is the rated current of the protected object.

In a steady state, the solution to the thermal differential equation is an e function whose asymptote represents the final overtemperature $Θ_{end}$. The time constant $τ_{th}$ determines the rise. After reaching an initial adjustable overtemperature threshold $Θ_{warn}$ (Threshold thermal warn.), a warning indication is given. If the overtemperature limit $Θ_{trip}$ (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 6-396 shows the temperature rise at different overload currents and the supervision thresholds.

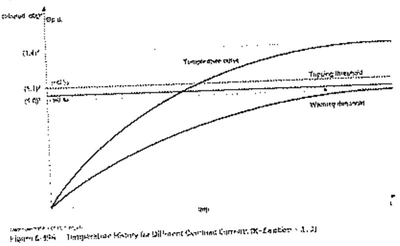


Figure 6-396 Temperature History for Different Overload Currents (K-factor = 1.1)

The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached.

The analysis of the RMS value of the current over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Ambient Temperature

This function can take the ambient temperature into consideration. The reference temperature of the thermal model is 40 °C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The Default temperature parameter can be used to fix or measure the ambient temperature. The Minimal temperature parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed as the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter Temperature rise at Irated).

The measured ambient temperature is recorded by an external RTD unit (RTD = Resistance Temperature Detector) and provided by the functions RTD unit Ether. or RTD unit serial of the function group Analog units. When using the Temperature sensor parameter, the respective temperature sensor can be selected. If the temperature measurement is disrupted, for example, due to an open circuit between the device and the RTD unit, the device will report it. In this case, the process continues with either the temperature measured last or the value set under the Default temperature parameter, whichever value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits). To avoid an overreaction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding I_{max}). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby retarded at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal K-factor of 1.1, a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the Dropout threshold operate, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are reduced at a fixed dropout threshold (see technical data).

Behavior in the Event of Auxiliary-Voltage Failure

The behavior of the thermal replica can be controlled upon auxiliary-voltage failure via the Storage of thermal replica parameter. You can save the thermal state for a down time of 500 min. If the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication >Reset thermal replica. The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Blocking the Function

Blocking will cause a picked up function to be reset. The function can be blocked externally or internally by the binary input signal >Block stage.

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal Block close can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Measured Value	Description
(_:310) Equival. current	Besides the thermal measured values in percent, the equivalent current is also output as a thermal current measured value (A or kA). The current equivalent is the primary current, which corresponds to the thermal measured value in percent, assuming steady-state conditions.
(_:304) Time until close	The Time until close is the expected time until it is possible for the protected object for reclosure. The calculation of this value is based on the assumption of constant currents. The thermal replica has then fallen below the setting value of the dropout threshold.
(_:305) Time until trip	The Time until trip is the expected time until tripping (100 % value exceeded) occurs. The calculation of this value is based on the assumption of constant currents.
(_:306) Overload	The value Overload indicates the current temperature of the protected object in percent. Tripping occurs if 100 % is exceeded.

6.45.4 Application and Setting Notes

Parameter: Threshold current warning

- Recommended setting value (_:101) Threshold current warning = 1.1 A for I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max,cont}$). This results in the same setting value as for K-factor.

Parameter: Threshold thermal warn.

- Recommended setting value (_:104) Threshold thermal warn. = 90 %

The default setting can be left at a K-factor of 1.1, because the thermal memory sets itself to 83 % at continuously flowing rated current. The calculation uses the rule of three. 100 % corresponds to (K-factor)² and x % corresponds to 1².

$$\frac{H}{Θ_{off}} = \frac{100\ \%}{K^2} = 83\ \%$$

At a K-factor of 1.05, the thermal memory for rated current is 91 % (lower). Increase the Threshold thermal warn. to 95 %.

Parameter: Dropout threshold operate

- Recommended setting value (_:105) Dropout threshold operate = 90 %

The Dropout threshold operate parameter is used to cancel pickup and tripping when the value drops below this threshold. A setting for the value of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, to avoid additional cooling or longer blocking of switching on.

The calculation of the operational measured value Time until close refers to this value.

Parameter: K-factor

- Recommended setting value (_:106) K-factor = 1.1

The K-factor parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated,obj}$ of the protected object (for example, resistance) is the basic current for overload sensing.

You can determine K-factor on the basis of the thermally permissible continuous current $I_{max,perm}$:

$$K\text{-factor} = \frac{I_{max,perm}}{I_{rated,obj}}$$

NOTE

The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer.

Siemens recommends using the default value as it is a typical value for many applications.

Parameter: Thermal time constant

- Default value (_:110) Thermal time constant = 900 s (15 min)

The Thermal time constant parameter is used to define the operate curve of the stage. If no time constant is given, you can derive it from other values.

EXAMPLE

Protection of a current-limiting resistance

Rated current of the resistance: I_{rated} = 100 A

Values for the overload capability:

- 1.1 I_{rated} permanent (K-factor = 1.1/ k = 1.1)
- 1.5 I_{rated} for 20 s for charge by cold

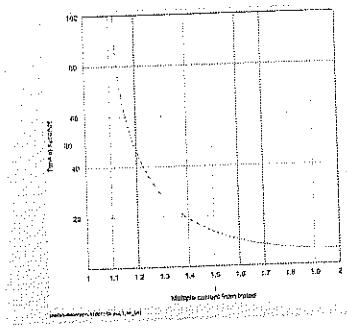
The following time constant results from these assumed values:

$$\tau_{th} = t \times \left[\ln\left(\frac{\left(\frac{I}{k \cdot I_{rated}}\right)^2}{\left(\frac{I}{k \cdot I_{rated}}\right)^2 - 1}\right)\right]^{-1} = 20\,s \times \left[\ln\frac{\left(\frac{1.5}{1.1}\right)^2}{\left(\frac{1.5}{1.1}\right)^2 - 1}\right]^{-1} = 20\,s \times \left[\ln\frac{1.86}{0.86}\right]^{-1} = 26\,s$$

For Thermal time constant, set 26 s.

The following time-dependent characteristic results from the data. In case of a current increase to 1.5 I_{rated} the tripping delay is 20 s.

1963



Parameter: Imax thermal

- Recommended setting value (_:107) Imax thermal = 2.5 A for I_{rated} = 1 A

The Imax thermal parameter allows you to set the threshold current for the Behav. at I> Imax therm. parameter. The selected current threshold of 2.5 $I_{rated,obj}$ is a practicable value.

Parameter: Temperature rise at Irated

- Default setting (_:109) Temperature rise at Irated = 70 K

NOTE

For an application as a 1-phase overload protection, the ambient temperature measured via the temperature sensor is not taken into account. Therefore, the setting has no influence. You can keep the default setting. If you take into account the temperature, note the following description.

Set the overtemperature as the value that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the Technical data of the equipment or you can measure the value. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.

When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40°C.

The overtemperature at maximum permissible current (ϑ_{max}) and the Temperature rise at Irated ($\vartheta_{rated, obj.}$) can be converted by using the following formula:

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$$k = \left(\frac{\Delta\vartheta_{max}}{\Delta\vartheta_{rated, obj}}\right)$$

EXAMPLE

Temperature class B for continuous operation: permissible overtemperature = 105 K
From this, a temperature for I_{rated} of 120°C (80 K + 40°C) can be derived when using a measuring element for the temperatures.
Temperature class F as thermal limiting value: permissible overtemperature = 105 K.
From this, a maximum temperature of 145°C (105 K + 40°C) derives.
From these values, the magnitude of the K-factor can also be derived:

$$k^2 = \frac{\Delta\vartheta_{max,perm}}{\Delta\vartheta_{rated,obj}} = \frac{105\,K}{80\,K} = 1.31 \Rightarrow k = 1.146$$

If selecting a setting value of 1.1 for the K-factor, your selection can be considered as conservative.

Parameter: Storage of thermal replica

- Recommended setting value (_:113) Storage of thermal replica = no

If a continuous auxiliary voltage of the bay units is ensured, the default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value (_:114) Behav. at I> Imax therm. = current limiting

The Behav. at I> Imax therm. parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be restricted.
The default setting has been selected compatible with SIPROTEC 4 devices. If you wish to take further temperature rise into consideration, the current limiting procedure is recommended.

Parameter Value	Description
current limiting	The input current is limited to the value set in the Imax thermal parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated,obj}$
freeze therm. rep.	If the input current exceeds the Imax thermal parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products.

Parameter: Temperature sensor

- Default setting (_:43) Temperature sensor = none

Use the Temperature sensor parameter to determine which temperature sensor to use to detect the ambient temperature.
A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and to feed it to the device via an RTD unit. The function Thermal overload protection receives the measured temperature values via the function RTD unit Ether. or RTD unit Serial from the function group Analog units.

Parameter: Default temperature

- Recommended setting value (_:118) Default temperature = 40°C

1965

Under the following conditions, the Default temperature will be set as ambient temperature:

- A temperature sensor for measuring the ambient temperature is not connected.
- The temperature measurement is interrupted and the measured temperature value is less than the Default temperature

Siemens recommends using the default setting.

Parameter: Minimal temperature

- Default setting (_:117) Minimal temperature = -20°C

If the measured ambient temperature drops below the preset value, the set value will be assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the Minimal temperature parameter, the Minimal temperature can also be used.

6.45.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting

1966

6.45.6 Information List

No.	Information	Data Class (Type)	Type
49 Th.overl. #			
_:500	49 Th.overl. #:>Block stage	SPS	I
_:501	49 Th.overl. #:>Reset thermal replica	SPS	I
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload	MV	O
_:310	49 Th.overl. #:Equival. current	MV	O

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6.46 Temperature Supervision

6.46.1 Overview of Functions

The Temperature supervision function checks the thermal state of:

- Motors
- Generators
- Transformers

In rotating machines, it also checks bearing temperatures for a limit violation.
The temperatures are measured at various locations of the protected object using temperature sensors (RTD = Resistance Temperature Detector) and are sent to the device via one or more RTD units.
The Temperature supervision function receives its measured temperature values via the RTD unit Ether. or Serial RTD unit functions from the Analog units function group.

6.46.2 Structure of the Function

The Temperature supervision function can work in all protection function groups. A maximum of 48 temperature supervision locations can operate simultaneously in the Temperature supervision function function. Each temperature supervision location has 2 threshold stages.

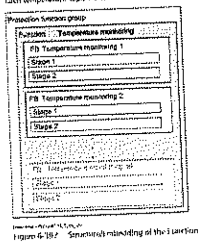

Figure 6-382 Structure/Embedding of the Function

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6.46.3 Function Description

Logic

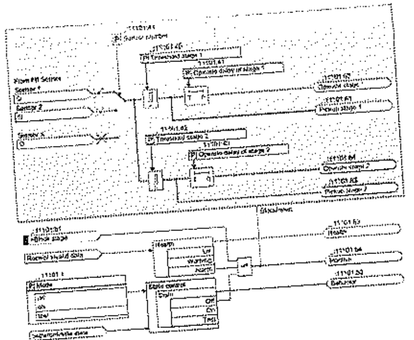

Figure 6-398 Logic Diagram for a Temperature Supervision Location

The Temperature supervision location function block (Location FB) receives a measured temperature value in °C or °F as an input variable delivered from the temperature sensor function blocks of the Analog units function group. The Sensor number parameter is used to select the temperature sensor.

2 threshold value decisions can be performed for each measuring point. If the measured temperature value is greater than or equal to the set threshold values, the stages generate a pickup indication independent of one another and, after a set tripping time delay, an operate indication.

The indications from the supervision locations remain available for further processing.

> **NOTE**
>
> The pickup of the stages does not result in fault logging. The operate indications of the stages do not go into the trip logic of the device.

6.46.4 Application and Setting Notes

If you use an external RTD unit, connect the RTD unit via an interface (Ethernet or serial) to the SIPROTEC 5 device. Observe the setting notes for configuration of the interfaces in chapter Analog Transformer Function Group Type under 10.7.3 Communication with an RTD unit.

Parameter: Sensor location

- Default setting (_:11101:46) Sensor location = Other

You inform the device of the sensor installation location using the Sensor location parameter. Oil, Ambient, Turn, Bearing and Other are available for selection. The selection is not evaluated in the device; it only serves an informational purpose as the medium in which the temperature measurement takes place.

Parameter: Sensor number

- Default setting (_:11101:44) Sensor number = no function block selected

With the Sensor number parameter, you assign a specific sensor whose temperature is to be monitored to the Location function block. You perform the assignment in DIGSI using a list box that contains all connected RTD units and their sensors.

Parameter: Threshold stage 1

- Default setting (_:11101:40) Threshold stage 1 = 100°C

With the Threshold stage 1 parameter you establish the temperature value whose exceedance causes a pickup of the 1st tripping stage.

Parameter: Operate delay of stage 1

- Default setting (_:11101:41) Operate delay of stage 1 = 5 s

With the Operate delay of stage 1 parameter you establish the time the operate indication of the 1st tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Parameter: Threshold stage 2

- Default setting (_:11101:42) Threshold stage 2 = 120°C

With the Threshold stage 2 parameter you establish the temperature value whose exceedance causes a pickup of the 2nd tripping stage.

Parameter: Operate delay of stage 2

- Default setting (_:11101:43) Operate delay of stage 2 = 0 s

With the Operate delay of stage 2 parameter you establish the time the operate indication of the 2nd tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Temperature Unit

Temperature Unit To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly (see 5.10.7.5 Temperature Sensor).

6.46.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Point 1				
_:11101:46	Point 1:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11101:1	Point 1:Mode		• off • on • test	off
_:11101:40	Point 1:Threshold stage 1		-50°C to 250°C	100°C
_:11101:41	Point 1:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11101:42	Point 1:Threshold stage 2		-50°C to 250°C	120°C
_:11101:43	Point 1:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11101:44	Point 1:Sensor		Setting options depend on configuration	
Point 2				
_:11102:46	Point 2:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11102:1	Point 2:Mode		• off • on • test	off
_:11102:40	Point 2:Threshold stage 1		-50°C to 250°C	100°C
_:11102:41	Point 2:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11102:42	Point 2:Threshold stage 2		-50°C to 250°C	120°C
_:11102:43	Point 2:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11102:44	Point 2:Sensor		Setting options depend on configuration	
Point 3				
_:11103:46	Point 3:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11103:1	Point 3:Mode		• off • on • test	off
_:11103:40	Point 3:Threshold stage 1		-50°C to 250°C	100°C
_:11103:41	Point 3:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11103:42	Point 3:Threshold stage 2		-50°C to 250°C	120°C
_:11103:43	Point 3:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11103:44	Point 3:Sensor		Setting options depend on configuration	
Point 4				
_:11104:46	Point 4:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11104:1	Point 4:Mode		• off • on • test	off
_:11104:40	Point 4:Threshold stage 1		-50°C to 250°C	100°C
_:11104:41	Point 4:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11104:42	Point 4:Threshold stage 2		-50°C to 250°C	120°C
_:11104:43	Point 4:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11104:44	Point 4:Sensor		Setting options depend on configuration	
Point 5				
_:11105:46	Point 5:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11105:1	Point 5:Mode		• off • on • test	off
_:11105:40	Point 5:Threshold stage 1		-50°C to 250°C	100°C
_:11105:41	Point 5:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11105:42	Point 5:Threshold stage 2		-50°C to 250°C	120°C
_:11105:43	Point 5:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11105:44	Point 5:Sensor		Setting options depend on configuration	
Point 6				
_:11106:46	Point 6:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11106:1	Point 6:Mode		• off • on • test	off
_:11106:40	Point 6:Threshold stage 1		-50°C to 250°C	100°C
_:11106:41	Point 6:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11106:42	Point 6:Threshold stage 2		-50°C to 250°C	120°C
_:11106:43	Point 6:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11106:44	Point 6:Sensor		Setting options depend on configuration	
Point 7				
_:11107:46	Point 7:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11107:1	Point 7:Mode		• off • on • test	off
_:11107:40	Point 7:Threshold stage 1		-50°C to 250°C	100°C
_:11107:41	Point 7:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11107:42	Point 7:Threshold stage 2		-50°C to 250°C	120°C
_:11107:43	Point 7:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11107:44	Point 7:Sensor		Setting options depend on configuration	
Point 8				
_:11108:46	Point 8:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11108:1	Point 8:Mode		• off • on • test	off
_:11108:40	Point 8:Threshold stage 1		-50°C to 250°C	100°C
_:11108:41	Point 8:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11108:42	Point 8:Threshold stage 2		-50°C to 250°C	120°C
_:11108:43	Point 8:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11108:44	Point 8:Sensor		Setting options depend on configuration	
Point 9				
_:11109:46	Point 9:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11109:1	Point 9:Mode		• off • on • test	off
_:11109:40	Point 9:Threshold stage 1		-50°C to 250°C	100°C
_:11109:41	Point 9:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11109:42	Point 9:Threshold stage 2		-50°C to 250°C	120°C
_:11109:43	Point 9:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11109:44	Point 9:Sensor		Setting options depend on configuration	
Point 10				
_:11110:46	Point 10:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other

Addr.	Parameter	C	Setting Options	Default Setting
_:11110:1	Point 10:Mode		• off • on • test	off
_:11110:40	Point 10:Threshold stage 1		-50°C to 250°C	100°C
_:11110:41	Point 10:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11110:42	Point 10:Threshold stage 2		-50°C to 250°C	120°C
_:11110:43	Point 10:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11110:44	Point 10:Sensor		Setting options depend on configuration	
Point 11				
_:11111:46	Point 11:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11111:1	Point 11:Mode		• off • on • test	off
_:11111:40	Point 11:Threshold stage 1		-50°C to 250°C	100°C
_:11111:41	Point 11:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11111:42	Point 11:Threshold stage 2		-50°C to 250°C	120°C
_:11111:43	Point 11:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11111:44	Point 11:Sensor		Setting options depend on configuration	
Point 12				
_:11112:46	Point 12:Sensor location		• Oil • Ambient • Turn • Bearing • Other	Other
_:11112:1	Point 12:Mode		• off • on • test	off
_:11112:40	Point 12:Threshold stage 1		-50°C to 250°C	100°C
_:11112:41	Point 12:Operate delay of stage 1		0 s to 60 s; ∞	5 s
_:11112:42	Point 12:Threshold stage 2		-50°C to 250°C	120°C
_:11112:43	Point 12:Operate delay of stage 2		0 s to 60 s; ∞	0 s
_:11112:44	Point 12:Sensor		Setting options depend on configuration	

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6.46.6 Information List

No.	Information	Data Class (Type)	Type
Point 1			
_:11101:81	>Point 1:>Block stage	SPS	I
_:11101:54	Point 1:Inactive	SPS	O
_:11101:52	Point 1:Behavior	ENS	O
_:11101:53	Point 1:Health	ENS	O
_:11101:61	Point 1:Pickup stage 1	SPS	O
_:11101:62	Point 1:Operate stage 1	SPS	O
_:11101:63	Point 1:Pickup stage 2	SPS	O
_:11101:64	Point 1:Operate stage 2	SPS	O
Point 2			
_:11102:81	Point 2:>Block stage	SPS	I
_:11102:54	Point 2:Inactive	SPS	O
_:11102:52	Point 2:Behavior	ENS	O
_:11102:53	Point 2:Health	ENS	O
_:11102:61	Point 2:Pickup stage 1	SPS	O
_:11102:62	Point 2:Operate stage 1	SPS	O
_:11102:63	Point 2:Pickup stage 2	SPS	O
_:11102:64	Point 2:Operate stage 2	SPS	O
Point 3			
_:11103:81	Point 3:>Block stage	SPS	I
_:11103:54	Point 3:Inactive	SPS	O
_:11103:52	Point 3:Behavior	ENS	O
_:11103:53	Point 3:Health	ENS	O
_:11103:61	Point 3:Pickup stage 1	SPS	O
_:11103:62	Point 3:Operate stage 1	SPS	O
_:11103:63	Point 3:Pickup stage 2	SPS	O
_:11103:64	Point 3:Operate stage 2	SPS	O
Point 4			
_:11104:81	Point 4:>Block stage	SPS	I
_:11104:54	Point 4:Inactive	SPS	O
_:11104:52	Point 4:Behavior	ENS	O
_:11104:53	Point 4:Health	ENS	O
_:11104:61	Point 4:Pickup stage 1	SPS	O
_:11104:62	Point 4:Operate stage 1	SPS	O
_:11104:63	Point 4:Pickup stage 2	SPS	O
_:11104:64	Point 4:Operate stage 2	SPS	O
Point 5			
_:11105:81	Point 5:>Block stage	SPS	I
_:11105:54	Point 5:Inactive	SPS	O
_:11105:52	Point 5:Behavior	ENS	O
_:11105:53	Point 5:Health	ENS	O
_:11105:61	Point 5:Pickup stage 1	SPS	O
_:11105:62	Point 5:Operate stage 1	SPS	O
_:11105:63	Point 5:Pickup stage 2	SPS	O

No.	Information	Data Class (Type)	Type
_:11105:64	Point 5:Operate stage 2	SPS	O
Point 6			
_:11106:81	Point 6:>Block stage	SPS	I
_:11106:54	Point 6:Inactive	SPS	O
_:11106:52	Point 6:Behavior	ENS	O
_:11106:53	Point 6:Health	ENS	O
_:11106:61	Point 6:Pickup stage 1	SPS	O
_:11106:62	Point 6:Operate stage 1	SPS	O
_:11106:63	Point 6:Pickup stage 2	SPS	O
_:11106:64	Point 6:Operate stage 2	SPS	O
Point 7			
_:11107:81	Point 7:>Block stage	SPS	I
_:11107:54	Point 7:Inactive	SPS	O
_:11107:52	Point 7:Behavior	ENS	O
_:11107:53	Point 7:Health	ENS	O
_:11107:61	Point 7:Pickup stage 1	SPS	O
_:11107:62	Point 7:Operate stage 1	SPS	O
_:11107:63	Point 7:Pickup stage 2	SPS	O
_:11107:64	Point 7:Operate stage 2	SPS	O
Point 8			
_:11108:81	Point 8:>Block stage	SPS	I
_:11108:54	Point 8:Inactive	SPS	O
_:11108:52	Point 8:Behavior	ENS	O
_:11108:53	Point 8:Health	ENS	O
_:11108:61	Point 8:Pickup stage 1	SPS	O
_:11108:62	Point 8:Operate stage 1	SPS	O
_:11108:63	Point 8:Pickup stage 2	SPS	O
_:11108:64	Point 8:Operate stage 2	SPS	O
Point 9			
_:11109:81	Point 9:>Block stage	SPS	I
_:11109:54	Point 9:Inactive	SPS	O
_:11109:52	Point 9:Behavior	ENS	O
_:11109:53	Point 9:Health	ENS	O
_:11109:61	Point 9:Pickup stage 1	SPS	O
_:11109:62	Point 9:Operate stage 1	SPS	O
_:11109:63	Point 9:Pickup stage 2	SPS	O
_:11109:64	Point 9:Operate stage 2	SPS	O
Point 10			
_:11110:81	Point 10:>Block stage	SPS	I
_:11110:54	Point 10:Inactive	SPS	O
_:11110:52	Point 10:Behavior	ENS	O
_:11110:53	Point 10:Health	ENS	O
_:11110:61	Point 10:Pickup stage 1	SPS	O
_:11110:62	Point 10:Operate stage 1	SPS	O
_:11110:63	Point 10:Pickup stage 2	SPS	O
_:11110:64	Point 10:Operate stage 2	SPS	O

No.	Information	Data Class (Type)	Type
Point 11			
_:11111:81	Point 11:>Block stage	SPS	I
_:11111:54	Point 11:Inactive	SPS	O
_:11111:52	Point 11:Behavior	ENS	O
_:11111:53	Point 11:Health	ENS	O
_:11111:61	Point 11:Pickup stage 1	SPS	O
_:11111:62	Point 11:Operate stage 1	SPS	O
_:11111:63	Point 11:Pickup stage 2	SPS	O
_:11111:64	Point 11:Operate stage 2	SPS	O
Point 12			
_:11112:81	Point 12:>Block stage	SPS	I
_:11112:54	Point 12:Inactive	SPS	O
_:11112:52	Point 12:Behavior	ENS	O
_:11112:53	Point 12:Health	ENS	O
_:11112:61	Point 12:Pickup stage 1	SPS	O
_:11112:62	Point 12:Operate stage 1	SPS	O
_:11112:63	Point 12:Pickup stage 2	SPS	O
_:11112:64	Point 12:Operate stage 2	SPS	O

6.47 Hotspot Calculation

6.47.1 Overview of Functions

The **Hotspot calculation** function (ANSI 49H) protects the transformer against thermal destruction at increased operating currents and monitors the thermal state of the turns.

The main use of this function is monitoring the temperature of the turns in the transformer. Continuously monitoring the temperature at special points, the hot spots, is very important. An increased turn temperature can have serious effects on the transformer.

The most frequent consequential damage of this is:

- Reduction of the service life
- Formation of gas bubbles that can result in insulation breakdown
- Destruction of the winding insulation

The hot-spot calculation considers the IEC 60076-7 and IEEE C57.91 2011 standards and calculates 3 relevant variables for the protection function:

- Hot-spot temperature
- Relative aging
- Load margin until warning and alarm indication

The following information about the protected object is necessary to calculate the hot spot temperature:

- Cooling methods
- Power factor
- Coolant temperature (top-oil temperature in the protected object)
- Transformer size
- Oil and turn time constants
- Factors as per IEC 60076-7 or IEEE C57.91 2011

The top-oil temperature is measured using temperature measuring points, in this case, up to 12 temperature measuring points can be transmitted to the protection device via one temperature coupling. One of these measuring points can be selected for calculation of the hot-spot temperature in the oil.

6.47.2 Structure of the Function

The Hot-spot calculation function can be used in every protection function group that has a 3-phase current input. During the engineering phase, you can incorporate the function into the project using drag & drop from the DIGSI 5 function library.

The Hot-spot calculation function is continuous.

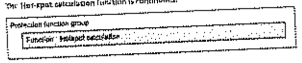

Figure 6-399 Structure/Embedding of the Function

6.47.3 Function Description

Logic of the Function

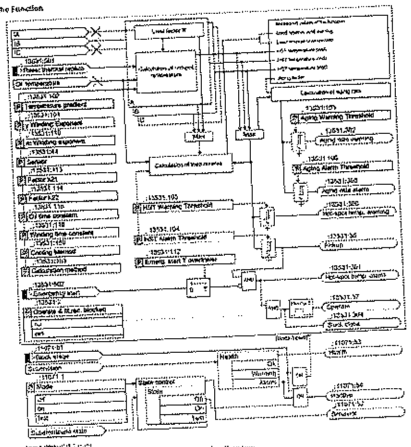

Figure 6-400 Logic Diagram of the Hotspot Calculation Function

The hotspot temperature of a transformer winding can be calculated according to IEC 60076-7 or IEEE C57.91 2011. The following 3 variables, relevant for the protection function, are calculated:

- Temperature at the hotspot in the protected object
- Relative aging
- Load margin until warning and alarm indication

Measurement of the top-oil temperature on the transformer is required for this function. Specify a measuring point for the temperature measuring equipment that is relevant for calculating the hotspot temperature.

Cooling Versions

Calculating the hotspot is dependent on the cooling method. Air cooling is always available and is differentiated into 2 convection types.

- AN (Air Natural): Artificial convection
- AF (Air Forced): Forced air convection (ventilation)

If a liquid coolant is also available, there are the following cooling versions:

- ON (Oil Natural – convective oil flow): The coolant (oil) moves in the tank due to the temperature differences that occur. The cooling effect coming from natural convection is not very pronounced.
- OF (Oil Forced – forced oil flow): The coolant (oil) moves in the tank because of an oil pump. The cooling effect is, for this reason, greater than for ON.
- OD (Oil Directed – directed oil flow): The coolant (oil) follows a directional route in the tank because of an oil pump. As a result, the oil flow can be increased at points that are particularly temperature critical. The cooling effect is particularly good for this reason, the temperature gradient is smallest.

Calculating the Hotspot Temperature According to IEC 60076-7

The hotspot of the protected object is an important state value. The hottest point of the transformer occurs on the insulation of the topmost inner turn and it is relevant for the service life. The coolant temperature in the transformer increases from the bottom to the top. The cooling method influences the magnitude of the temperature gradient.

The hotspot temperature is composed of 3 components:

- Temperature at the hottest point in the coolant (coupled in by way of temperature measurement)
- Component coming from the temperature increase of the turn caused by the transformer load. It specifies the temperature gradient from the hotspot of the winding to the top-oil temperature
- Component of the temperature rise of the turn due to a sudden change in the transformer load

To calculate the temperature at the hotspot, the protection device needs the following information:

- Data from the top-oil measuring point
- Data on the current in the winding
- Settings of the characteristic properties of the cooling system

An indication and/or tripping is generated if an adjustable threshold (temperature alarm) is exceeded.

To calculate the hotspot inside the transformer, the sum is formed from the top-oil temperature and the temperature difference between the hotspot and the top-oil:

$\Theta_h(t) = \Theta_o(t) + \Delta\Theta_h(t)$

with

$\Theta_h(t)$	Temperature at the hotspot in °C
$\Theta_o(t)$	Top coolant temperature (oil temperature) in °C
$\Delta\Theta_h(t)$	Temperature difference between the hotspot of the winding and the oil in °C

The following 2 factors determine the temperature ratio between the hotspot and the oil temperature:

- Change in the oil viscosity (flow behavior of the oil)
- Change in the ohmic turn resistance (load-dependent)

$\Delta\Theta_h(t) = \Delta\Theta_{h1}(t) - \Delta\Theta_{h2}(t)$

$\Delta\Theta_{h1}(t) = \Delta\Theta_{h1}(t-1) + d\Delta\Theta_{h1}(t)$

$\Delta\Theta_{h2}(t) = \Delta\Theta_{h2}(t-1) + d\Delta\Theta_{h2}(t)$

with

$\Delta\Theta_{h1}(t)$	Temperature difference due to the turn resistance
$\Delta\Theta_{h2}(t)$	Temperature difference due to the oil viscosity

The following 2 equations are used for the calculation:

$$\Delta\theta_{h1}(t) = \frac{\Delta t}{k_{22}\cdot\tau_w}\cdot\left(k_{21}\cdot K^y\cdot H_{gr} - \Delta\theta_{h1}(t - \Delta t)\right)$$

$$\Delta\theta_{h2}(t) = \frac{\Delta t}{(1/k_{22})\cdot\tau_o}\cdot\left((k_{21}-1)\cdot K^y\cdot H_{gr} - \Delta\theta_{h2}(t - \Delta t)\right)$$

with

H_{gr}	Insulation temperature gradient
K	Load ratio I/I_r (measured)
y	Turn exponent
k_{21}, k_{22}	Constants of the thermal model
τ_o	Oil time constant
τ_w	Turn time constant
t	Current calculation time point
Δt	Calculation interval

During this, the load ratio K is determined from the measured current of one side and the rated object current. The rated current of the appropriate function group is used as the rated object current.

Calculating the Hotspot Temperature According to IEEE C57.91 2011

To calculate the hotspot inside the transformer, the sum is formed from the top-oil temperature and the temperature difference between the hotspot and the top oil. The equation corresponds to the IEC standard:

$\theta_h(t) = \theta_o(t) + \Delta\theta_h(t)$

with

$\theta_h(t)$	Temperature of the hotspot in °C
$\theta_o(t)$	Top-coolant temperature (oil temperature) in °C
$\Delta\theta_h(t)$	Temperature difference between the hotspot of the winding and the oil in °C

$$\Delta\theta_h(t) = \Delta\theta_h(t - \Delta t) + \frac{\Delta t}{\tau_w}\left(\Delta\theta_{h,U}(t) - \Delta\theta_h(t - \Delta t)\right)$$

$\Delta\theta_{h,U}(t) = K^{2m}\cdot H_g$

with

$\Delta\theta_{h,U}(t)$	Load-dependent hotspot temperature increase via the top-oil temperature
K	Load ratio I/I_r (measured)
m	Turn exponent
H_g	Temperature gradient from the turn hotspot to the oil temperature at rated load
τ_w	Turn time constant
t	Current calculation time point
Δt	Calculation interval

The following graphic shows an example for the behavior of the hotspot temperature during a load jam of 0 - I/I_r to 1 - I_r, and a steady oil temperature of 70 °C. All required settings correspond to the default values. The results of the calculation methods according to IEC 60076-7 and IEEE C57.91 2011 are compared.

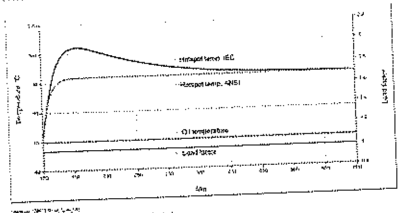

Figure 6-481 Example of a Hotspot Calculation

Calculation of the Relative Aging

The service life of cellulose insulation refers to a temperature of 98 °C in the immediate environment of the insulation. Experience has shown that an increase of 6 K cuts the service life in half. This yields the following equation for a relative aging V at a temperature different from 98 °C:

$$V = \frac{\text{Aging at } \theta_h}{\text{Aging at } 98\ ^\circ C} = 2^{(\theta_h - 98)/6}$$

with

V	Relative aging
θ_h	Temperature of the hotspot in °C

The mean relative aging rate L results from forming the average over an observed time lapse from T1 to T2. The time period between T1 and T2 is 1 min.

$$L = \frac{1}{T_2 - T_1}\int_{T_1}^{T_2} V\,dt$$

with

L	Mean relative aging
T2 - T1	60 s

At a steady rated load, L = 1 corresponds to a hotspot temperature of 98 °C; at values over 1, accelerated aging occurs. For example, at L = 2 only half the service life is reached with respect to normal load conditions. The relative aging is defined according to IEC only in the range from 80 °C to 140 °C. This is the defined working range of the aging calculation. Temperatures below 80 °C do not extend calculated aging. Values exceeding 140 °C do not result in a reduction in the calculated aging.

The calculation of relative aging described refers only to the winding insulation and is, for this reason, not applicable for other failure causes.

Results

The hotspot temperature is calculated for the transformer function group of the protected object. The currents of this function group and the measured coolant temperature at a selected temperature measuring point are used for this. The rated object current of the appropriate function group is used as the rated current.

Hotspot Thresholds

There are 2 indication thresholds for the hotspot temperature: a warning threshold HST Warning Threshold and an alarm threshold HST Alarm Threshold. There is also one adjustable threshold each for warning Aging Warning Threshold and alarm Aging Alarm Threshold for the mean aging rate.

Emergency Start

If the transformer must be operated beyond the maximum permissible hotspot temperature for operational reasons, the trip command can be blocked or a closure made possible by way of a binary input (>Emergency start).

After the binary input signal >Emergency start drops out, it may be necessary for the blocking to stay in effect because the hotspot temperature determined is still above the trip threshold. For this reason, the protection function is equipped with an adjustable run-on time (Emerg. start T overtravel) that starts when the binary input signal drops and continues to suppress the trip command. Tripping by the hotspot calculation is only possible again after this time has elapsed.

This binary input acts only on the alarm indication and the trip command, has no effect on fault logging and does not reset the thermal image.

Blocking the Function

In the event of blocking, the picked up function will be reset. The function can be blocked externally or internally by the binary input signal >Block stage. All indications drop out with this.

Blocking Closure

The signal Block close can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping temperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Measured Value	Description
(_:13531:307) Tmp.A	Hotspot temperature for phase A in °C or °F (depending on the setting)
(_:13531:308) Tmp.B	Hotspot temperature for phase B in °C or °F (depending on the setting)
(_:13531:309) Tmp.C	Hotspot temperature for phase C in °C or °F (depending on the setting)
(_:13531:310) Tmpmax	Hotspot temperature for the 3 phases in °C or °F (depending on the setting)
(_:13531:311) AgRate	Relative aging rate
(_:13531:305) ResWarn	Load margin until warning indication in percent
(_:13531:306) ResAlm	Load margin until alarm indication in percent

You can read the current status at any time on the device under the functional measured value.

You can find the functional measured values for the Hotspot calculation under the following menu item of the device:

- Main menu → Measurements → Function → Functional Measured Values → Hotspot calculation

6.47.4 Application and Setting Notes

Parameter: Sensor

- Default setting (_:13531:44) Sensor = No function block selected

Using the Sensor settings, you specify which connected temperature measuring point is used for hot spot calculation. The sensor for measuring the top-oil temperature must be connected to this temperature measuring point. If no temperature measuring equipment is connected, the Consistency failure parameter is displayed.

Parameter: Cooling Method

- Default setting (_:13531:160) Cooling Method = ONAN Oil nat.Air nat.

Using the Cooling Method setting, you specify the cooling method. You will find the definitions under the margin title Cooling versions in the function description of the hot-spot calculation.

Parameter: Emerg. start T overtravel

- Default setting (_:13531:112) Emerg. start T overtravel = 300 s

The Emerg. start T overtravel setting is used to set the time for which blocking of the tripping has to remain active after the outgoing input signal >Emergency start. With an outgoing input signal, the load on the protected object is removed. The Emerg. start T overtravel is set so that the hot-spot temperature can drop below the dropout threshold in this time.

Parameter: HST Warning Threshold

- Default setting (_:13531:103) HST Warning Threshold = 98 °C

Using the HST Warning Threshold setting, you set a temperature at which a warning is output when this temperature is exceeded.

Parameter: HST Alarm Threshold

- Default setting (_:13531:104) HST Alarm Threshold = 108 °C

Using the HST Alarm Threshold setting, you set a temperature at which an alarm is output when this temperature is exceeded.

Parameter: Aging Warning Threshold

- Default setting (_:13531:105) Aging Warning Threshold = 1.000

Using the Aging Warning Threshold setting, you set the threshold value at which a warning indication of the calculated relative aging is output.

Parameter: Aging Alarm Threshold

- Default setting (_:13531:106) Aging Alarm Threshold = 2.000

Using the Aging Alarm Threshold setting, you set the threshold value at which an alarm indication of the calculated relative aging is output.

Parameter: Turn time constant

- Default setting (_:13531:114) Turn time constant = 10 min

Using the Turn time constant setting, you account for the heat transfer from an electrical conductor (turn) to the outside of the insulation. This takes a few minutes. If no appropriate specifications are available, those found in IEC 60076-7 or IEEE C57.91 2011 may be used. You can find an excerpt from the tables of these standards with the data relevant here in Table 6-19.

Parameter: Calculation method

- Default setting (_:13531:163) Calculation method = IEC 60076-7

Using the Calculation method setting, you specify the standard used for calculating the hotspot temperature. Depending on the selection, the required setting values are either displayed or hidden.

IEC 60076-7

The following settings apply only for the calculation method according to the IEC 60076-7 standard.

Parameter: y Turn exponent

- Default setting (_:13531:101) y Turn exponent = 1.6

To calculate the hot-spot temperature, the device requires the y Turn exponent. If no specifications are available, those found in IEC 60076-7 may be used. You can find an excerpt from the tables of these standards with the data relevant here in Table 6-19.

Parameter: Temperature gradient

- Default setting (_:13531:102) Temperature gradient = 22

To calculate the hot-spot temperature, the device requires the Temperature gradient (H_{gr}). This temperature gradient specifies the temperature difference between the hot spot of the winding and the top-oil temperature at rated load.

The setting is unitless. The temperature gradient is specified in °C (SI unit). If the value is only known for °F, convert it according to the following equation:

°C = K · 5/9

°C	Value in °C
K	Temperature gradient in °F

If no specifications are available, those found in IEC 60076-7 may be used. You can find an excerpt from the tables of this standard with the data relevant here in Table 6-19.

Parameter: Factor k21

- Default setting (_:13531:113) Factor k21 = 2.0

Parameter: Factor k22

- Default setting (_:13531:114) Factor k22 = 2.0

The settings Factor k21 and Factor k22 are model constants that account for the turn configuration of the transformer with regard to oil flow. If no specifications for the transformer in question are available, those found in IEC 60076-7 may be used. You can find an excerpt from the tables of this standard with the data relevant here in Table 6-19.

Parameter: Oil time constant

- Default setting (_:13531:115) Oil time constant = 210 min

The Oil time constant settings account for oil flow and flow rate. The time constant depends on the winding type and the cooling method. If no specifications are available, those found in IEC 60076-7 may be used. You can find an excerpt from the tables of this standard with the data relevant here in Table 6-19.

IEEE C57.91 2011

The following settings apply only for the calculation method according to the IEEE C57.91 2011 standard.

Parameter: n Turn exponent

- Default setting (_:13531:110) n Turn exponent = 0.8

To calculate the hot spot temperature, the device requires the n Turn exponent. If no specifications are available, those found in IEEE C57.91 2011 may be used. You can find an excerpt from the tables of this standard with the data relevant here in Table 6-19.

Parameter: Temperature gradient

- Default setting (_:13531:100) Temperature gradient = 22

To calculate the hot-spot temperature, the device requires the Temperature gradient (H_g). This temperature gradient specifies the temperature difference between the hot spot of the winding and the top-oil temperature at rated load.

The setting is unitless. The temperature gradient is specified in °C (SI unit). If the value is only known for °F, convert it according to the following equation:

°C = K · 5/9

°C	Value in °C
K	Temperature gradient in °F

If no specifications are available, those found in IEEE C57.91 2011 may be used. You can find an excerpt from the tables of this standard with the data relevant here in Table 6-19.

Thermal Data of Transformers

If no specifications for the transformer in question are available, those found in the IEC 60076-7 or IEEE C57.91 2011 standards may be used. You can find an excerpt from the tables of these standards with the data relevant here in the table below.

Table 6-19 Thermal Data of Transformers

		Distribution Transformers	Medium-Size and Large Power Transformers						
Cooling methods		ONAN	ONAN[1]	ONAN	ONAF[1]	ONAF	OF[1]	OF	OD
Turn exponent (IEC)	y	1.6	1.3	1.3	1.3	1.3	1.3	1.3	2.0
Turn exponent (ANSI)	m	0.8	0.65	0.65	0.65	0.65	0.65	0.65	1.0
Constant	k_{21}	1.0	3.0	2.5	3.0	2.0	1.45	1.3	1.0
Constant	k_{22}	2.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0
Oil time constant	τ_o [min]	180	210	210	150	150	90	90	90
Turn time constant	τ_w [min]	4	10	10	7	7	7	7	7
Insulation temperature gradient	H_{gr} [°C]	23	-	26	-	26	-	22	29

[1] If the turns of an ON-cooled or OF-cooled transformer are cooled in a zigzag connection.

6.47.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:13531:1	Hotspot calc.:Mode		• off • on • test	off
_:13531:2	Hotspot calc.:Operate & flt.rec. blocked		• no • yes	no
_:13531:100	Hotspot calc.:Consistency failure		• no MV configured • no sensor configured	no sensor configured

Addr.	Parameter	C	Setting Options	Default Setting
_:13531:130	Hotspot calc.:Cooling Method		• ONAN Oil nat.&Air nat. • ONAF Oil nat.&Air for. • OF Oil forced • OD Oil directed	ONAN Oil nat.&Air nat.
_:13531:112	Hotspot calc.:Emerg. start (overrides)		0 s to 15 000 s	300 s
_:13531:103	Hotspot calc.:HST Warning Threshold		80 °C to 140 °C	98 °C
_:13531:104	Hotspot calc.:HST Alarm Threshold		80 °C to 140 °C	108 °C
_:13531:105	Hotspot calc.:Aging Warning Threshold		0.125 to 128.000	1.000
_:13531:106	Hotspot calc.:Aging Alarm Threshold		0.125 to 128.000	2.000
_:13531:116	Hotspot calc.:Turn time constant		4 min to 30 min	10 min
_:13531:153	Hotspot calc.:Calculation method		• IEC 60076-7 • IEEE C57.91 2011	IEC 60076-7
IEC 60076-7				
_:13531:101	Hotspot calc.:y Turn exponent		1.6 to 2.0	1.6
_:13531:102	Hotspot calc.:Temperature gradient		20 to 50	22
_:13531:113	Hotspot calc.:Factor k21		1.0 to 5.0	2.0
_:13531:114	Hotspot calc.:Factor k22		1.0 to 5.0	2.0
_:13531:115	Hotspot calc.:Oil time constant		60 min to 800 min	210 min
IEEE C57.91 2011				
_:13531:110	Hotspot calc.:m Turn exponent		0.8 to 1.0	0.8
_:13531:130	Hotspot calc.:Temperature gradient		20 to 50	22

6.47.6 Information List

No.	Information	Data Class (Type)	Type
Hotspot calc.			
_:13531:81	Hotspot calc.:>Block stage	SPS	I
_:13531:502	Hotspot calc.:>Emergency start	SPS	I
_:13531:501	Hotspot calc.:>Reset thermal replica	SPS	I
_:13531:54	Hotspot calc.:Inactive	SPS	O
_:13531:52	Hotspot calc.:Behavior	ENS	O
_:13531:53	Hotspot calc.:Health	ENS	O
_:13531:300	Hotspot calc.:Hotspot temp. warning	SPS	O
_:13531:301	Hotspot calc.:Hotspot temp. alarm	SPS	O
_:13531:302	Hotspot calc.:Aging rate warning	SPS	O
_:13531:303	Hotspot calc.:Aging rate alarm	SPS	O
_:13531:55	Hotspot calc.:Pickup	ACD	O

No.	Information	Data Class (Type)	Type
_:13531:57	Hotspot calc.:Operate	ACT	O
_:13531:304	Hotspot calc.:Block close	SPS	O
_:13531:307	Hotspot calc.:Time A	MV	O
_:13531:308	Hotspot calc.:Time B	MV	O
_:13531:309	Hotspot calc.:Trip T	MV	O
_:13531:310	Hotspot calc.:TempAg	MV	O
_:13531:311	Hotspot calc.:AgRate	MV	O
_:13531:305	Hotspot calc.:dtoWarn	MV	O
_:13531:306	Hotspot calc.:RsAlm	MV	O

6.48 Circuit-Breaker Failure Protection

6.48.1 Overview of Functions

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

6.48.2 Structure of the Function

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

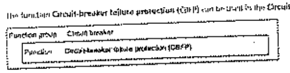

Figure 6-402 Structure/Embedding of the Function

Figure 6-403 shows the functionalities and the function control of the function.

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

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

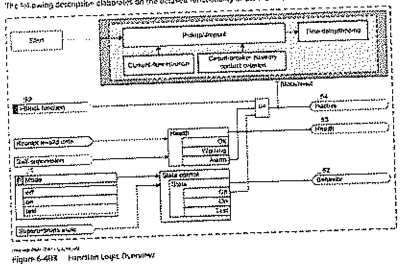

Figure 6-403 Function Logic Overview

6.48.3 Function Description

The Circuit-breaker failure protection function is started by device-internal protection functions and/or externally (via a binary input or an interface, such as GOOSE). Figure 6-404 and Figure 6-405 show the functionality.

Internal Start

By default, each device-internal protection stage, which has to control the local circuit breaker, starts the circuit-breaker failure protection. The function is started by the tripping of the protection stage. In the default setting, the starting signal Internal start (see Figure 6-404) is held when the pickup signal has a falling edge or the protection function has tripped. The Circuit-breaker failure protection function can in this case only drop out if the circuit breaker is detected to be open. This is detected using the current flow or circuit-breaker auxiliary contact criterion. If necessary, the Circuit-breaker failure protection function can also drop out when the pickup signal has a falling edge or the protection function trips (Internal starting signal is not held).

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

The internal starting sources are routed in the protection function groups via the Circuit breaker interaction entry (for this, see 2.1 Function Embedding in the Device, Figure 2-6).

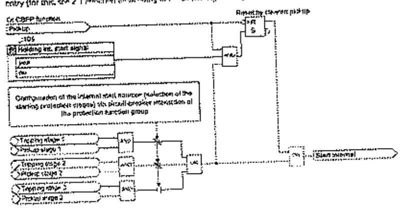

Figure 6-404 Internal Start of the Circuit-Breaker Failure Protection Function

External Start

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

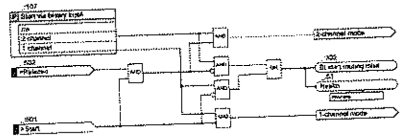

Figure 6-405 Configuration of the External Start of the Circuit-Breaker Failure Protection Function

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

In 2-channel operation, the binary input signal >Release must also be activated to initiate the start. In the default setting, the starting signal External start drops out immediately when the input signals have a falling edge (see Figure 6-406). If necessary, the starting signal can be held. In this case the start remains active when the binary input signals have a falling edge.

Supervision is disabled in the following cases:

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

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

The binary input signals only take effect if the binary inputs are activated for at least 10 ms (SW filter, see Figure 6-406).

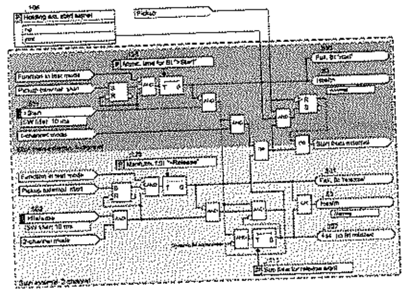

Figure 6-406 External Start of the Circuit-Breaker Failure Protection Function, Logic

Current-Flow Criterion

The current-flow criterion is the primary criterion for determining the circuit-breaker position. A circuit breaker pole is supposed to be closed, and the current-flow criterion fulfilled, as soon as one of the phase currents exceeds the phase-current threshold value, and at the same time a plausibility current exceeds the associated threshold value.

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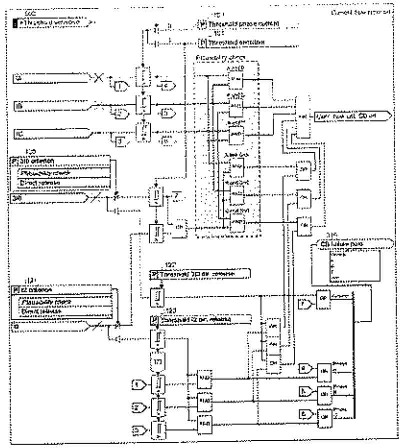

Figure 6-407 Current-Flow Criterion

Circuit-Breaker Auxiliary-Contact Criterion

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

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

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

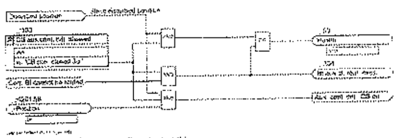

Figure 6-408 Circuit-Breaker Auxiliary-Contact Criterion

Pickup/Dropout

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

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

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

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

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

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

In the default setting, the internal starting signal is held (see Figure 6-406 and Figure 6-409). This means that dropout is controlled solely by the switch or the circuit-breaker auxiliary-contact criterion. If dropout is also to occur on the falling edge of the starting signal (that is, when the pickup signal has a falling edge or the protection function trips), holding of the start signal must be disabled.

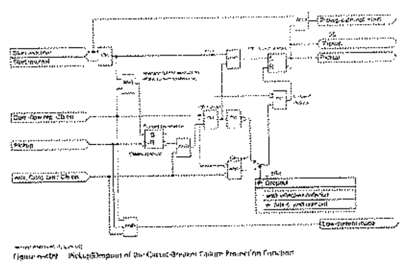

Figure 6-409 Pickup/Dropout of the Circuit-Breaker Failure Protection Function

Delay/Tripping

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

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

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

You can find detailed information in the chapter 3.5.3 Protection Interface and Protection Topology.

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

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

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

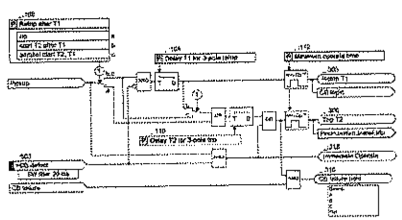

Figure 6-410 Delay/Tripping of the Circuit-Breaker Failure Protection Function

6.48.4 Application and Setting Notes

Figure 6-411 gives an overview of the functions involved in an external start of the CBFP function. In the case of an internal start, there is no external protection device and the protection functionality is located in the CBFP device.

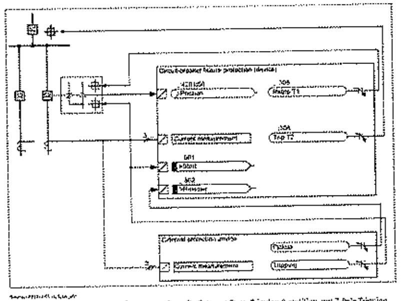

Figure 6-411 Circuit-Breaker Failure Protection with External Start, Tripping Repetition and 3-Pole Tripping (T2)

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

Configuration of the internal starting sources takes place in the protection function groups via the Circuit-breaker interaction entry (for this, see 2.1 Function Embedding in the Device, Figure 2-2).

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

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

Parameter: Start via binary input

- Default setting (_:102) Start via binary input = no

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

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

Input Signals: >Start, >Release

The start and release input signals have a filtering time of 10 ms as default setting. If a transient control signal to the binary inputs is to be expected due to the design of the external binary input control circuits and due to environmental conditions, the filtering time can be extended. This delays the start of the CBFP function.

Input Signals	Description
>Start	The start input signal is linked with the tripping of the external protection device (see Figure 6-411).
>Release	The release input signal is normally linked with the pickup of the external protection device (see Figure 6-411). Another common configuration is the parallel wiring of the external trip indication to both binary inputs (start and release).

Parameter: Supervision time release signal

- Default setting (_:113) Sup.time for release signal = 0.06 s

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

Parameter: Holding internal signal

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

Parameter Value	Description
yes	For an internal start, the starting signal is held by default. The dropout of the CBFP depends exclusively on the determination of the CB position. This setting must be selected if it is not ensured that all 3 poles of the CB have opened when the pickup signal of the protection function has a falling edge. Siemens recommends using this method as the standard method.
no	Holding of the starting signal can be done so if it is ensured by the application that the CB has safely opened when the starting signal has a falling edge, or if the CBFP is explicitly required to dropout when the starting signal has a falling edge.

EXAMPLE

Holding internal starting signal (setting value yes)

In the event of a 2-pole fault, only one contact of the CB opens. The fault current is thus reduced, and the starting phase short-circuit protection drops out.

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Parameter: Holding ext. start signal

- Recommended setting value (_:106) Holding ext. start signal = no

Parameter Value	Description
no	The CBFP drops out when the external starting signal has a falling edge. This setting prevents the CBFP from generating a tripping signal when an unwanted pulse is received at the binary input and the current flow is high enough. Siemens recommends using this method as the standard method.
yes	You can hold the starting signal if it is not ensured that the circuit breaker is open when the external starting signal has a falling edge.

EXAMPLE

Holding external starting signal (setting value yes)

The function is started from the opposite end via an auxiliary device for command transmission. This device generates only a signal pulse.

NOTE

Siemens would like to point out that, with a hold signal, the CBFP generates a trip signal each time a starting pulse is received and the current flow is high enough. Remember this particularly in the case of an external start.

Parameter: Threshold phase current/Threshold sensitive

- Recommended setting value (_:102) Threshold phase current = approx. 0.50 I_{rated}
- Recommended setting value (_:101) Threshold sensitive = approx. 0.50 I_{rated}

In order to ensure that the disconnection of the fault is promptly detected and the function can drop out quickly, Siemens recommends setting both thresholds to half the minimum short-circuit current ($I_{sc,min}$).

If – depending on the neutral-point treatment and/or load conditions – ground faults lead to relatively low fault currents, a sensitive setting of the parameter Threshold sensitive must be selected according to the rule ($0.5 I_{sc,min}$). There can also be values which are noticeably below the rated or load current.

Input Signal: >Threshold sensitive

In order to ensure that the function picks up reliably in all switch positions of the power-supply system (examples, opposite end of line open, switching onto a ground fault), the setting of the parameter Threshold sensitive can be applied dynamically to all currents – including phase currents – in the presence of ground faults. For this purpose, the binary signal >Threshold sensitive must be activated. This can be done via a device-internal function for ground-fault detection (if provided in the device), for example, using Overvoltage protection with zero-sequence voltage. In this case, the pickup of the V0> function must be linked with the binary signal. Alternatively, the signal can be coupled from a separate device for sensitive ground-fault detection via a binary input.

Parameter: Circuit-breaker auxiliary-contact criterion allowed for protection

- Recommended setting value (_:103) CB aux.cont. crit. allowed = no

Parameter Value	Description
no	If sufficient current flow is ensured under all conditions with the CB closed, Siemens recommends not to permit the auxiliary contacts as a further criterion for determining the CB position, because measurement based on the current flow is the most reliable criterion.

Parameter Value	Description
w. "CB pos. closed 3p."	The auxiliary contact is permitted as a further criterion in applications (see the following examples) where the current is no reliable criterion for determining the circuit-breaker position.

Parameter: 3I0 criterion

- Recommended setting value (_:120) 3I0 criterion = Plausibility check

Parameter Value	Description
Plausibility check	The ground current serves only for the plausibility check of the phase currents. The threshold for the ground current uses the value set in the Threshold sensitive parameter.
Direct release	The current-flow criterion can be satisfied only by the ground current without the phase currents exceeding the set threshold value. The threshold for the ground current uses the value set in the Threshold 3I0 dir. release parameter in this case.

Parameter: I2 criterion

- Recommended setting value (_:121) I2 criterion = Plausibility check

Parameter Value	Description
Plausibility check	The negative-sequence current serves only for the plausibility check of the phase currents. The threshold for the negative-sequence current uses the value set in the Threshold sensitive parameter.
Direct release	If one phase current exceeds 1% of the Threshold I2 dir. release, the current-flow criterion can be satisfied just by the negative-sequence current without the phase currents exceeding their set threshold value. The threshold for the negative-sequence current uses the value set in the Threshold I2 dir. release parameter in this case.

EXAMPLES

Applications which require you to permit the circuit-breaker auxiliary-contact criterion:

- Tripping of the high and low-voltage side CB on the transformer. If only one of the 2 CBs trips, there is no more current flow.
- Tripping of protection functions whose tripping decision is not based on current measurement, in combination with low load situations.
- Injection of the tripping signal from Buchholz protection

Parameter: Dropout

- Recommended setting value (_:104) Dropout = with effective criterion

The parameter Dropout is available if the circuit-breaker auxiliary contact criterion is permitted (see parameter CB aux.cont. crit. allowed).

Parameter Value	Description
with effective criterion	Siemens recommends keeping the default setting, because it prefers the current as a reliable criterion for detection of an open CB and thus for dropout of the CBFP function
w. aux.c. and curr.crit.	Select this setting for applications on transformers or generators (see the preceding examples) in which the current flow is such that the current is no longer a reliable criterion for detecting the opening of the CB.

Parameter: Retrip

- Default setting (_:108) Retrip after T1 = no

Parameter Value	Description
no	Where no redundant CB control is provided, a repetition of the trip signal to the local CB is not required.
start T2 after T1	Where a redundant CB control (2nd trip coil with 2 trip circuits) is provided, a repetition of the trip signal to the local CB makes sense. Siemens recommends the setting start T2 after T1 because it provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember here that the overall fault-clearance time in case of a failure of the local CB is the sum of T1 and T2.
parallel start T2, T1	As an alternative to the setting start T2 after T1, the user can start T2 and T1 in parallel.

Parameter: Delay T1 for 3-pole retrip

- Default setting (_:109) Delay T1 for 3-pole retrip = 0.05 s

The parameter is visible only when retripping is set.

The setting depends on the user's philosophy.

The following settings make sense:

- If the minimum fault-clarification time has top priority, Siemens recommends setting the time to 0. This setting causes initiation of the retrip immediately upon the start. The drawback is that a defect of the 1st trip circuit is not detected.
- With a small time delay of, for instance, 50 ms, the defect of the 1st trip circuit can be detected based on the evaluation of the fault record.
- With a long time delay which reliably ensures the dropout of the CBFP with the CB open, the rising edge indication of the trip repeat Retrip T1 is a sure signal for a fault in the 1st trip circuit. The following example shows how this time is determined

EXAMPLE

Determining the T1 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by the device-internal protection)	5 ms
CB inherent time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T1)	130 ms

Parameter: Delay T2 for 3-Pole Trip

- Default setting (_:110) Delay T2 for 3-pole trip = 0.13 s

This setting has to ensure that after opening of the local CB the function drops out reliably and that backup tripping is avoided under all circumstances. The setting depends on the parameter Retrip after T1.

If T2 is started after T1, there is no need to consider the time T1 for the setting of T2.

EXAMPLE

Determining the T2 Time that Reliably Ensures the Dropout of the CBFP with the CB Open:

Time of binary device output (when tripping is caused by the device-internal protection)	15 ms
CB inherent time up to current interruption	2 periods (assumed rated frequency = 50 Hz)
Dropout time of CBFP function	1 period
Subtotal	65 ms
Security	Factor 2
Total (time T2)	130 ms

If T1 and T2 are started in parallel, take into account the time T1 for the setting of T2.

EXAMPLE

Simultaneous start of T2 and T1

Time for a reliable dropout after the local CB has opened	130 ms
Setting of T1	50 ms
Total (= T2)	180 ms

Parameter: Minimum operate time

- Default setting (_:112) Minimum operate time = -

The Minimum operate time parameter is used to set the minimum duration for tripping the function.

⚠ CAUTION

Do not set a time that is too short.

If you set a time that is too short, there is a danger (dropout of the function without the current-flow criterion) that the device contacts will interrupt the control circuit. If this happens, the device contacts will burn out.

◇ Set a duration that is long enough to ensure that the circuit breaker reaches its final position open reliably after a control operation.

Input Signal: >CB defect

The input signal >CB defect has a default filtering time of 20 ms. This filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the pressure change when the CB opens.

This time can be set to 0 if such a transient pickup of the physical binary input can be excluded due to the CB design.

Output Signal: Retrip T1

If only one control circuit is available for the local CB, it is not mandatory to route the output signal because the signal also controls the CB trip logic.

If a 2nd control circuit is present, the output signal Retrip T1 must be routed to the associated binary output.

Output Signal: Trip T2

In order to operate the adjacent circuit breakers, the backup tripping (indication Trip T2) must be routed to a binary output and if necessary, to an interface (intertripping to opposite end).

6.48.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
SOBF CB fail.#				
_:1	SOBF CB fail.#:Mode		• off • on • test	off
_:105	SOBF CB fail.#:Holding int. start signal		• no • yes	yes
_:107	SOBF CB fail.#:Start via binary input		• no • 2 channel • 1 channel	no
_:106	SOBF CB fail.#:Holding ext. start signal		• no • yes	no
_:111	SOBF CB fail.#:Sup.time for release signal		0.06 s to 1.00 s	0.06 s
_:103	SOBF CB fail.#:CB aux.cont. crit. allowed		• no • w. "CB pos. closed 3p."	no
_:104	SOBF CB fail.#:Dropout		• with effective criterion • w. aux.c. and curr.crit.	with effective criterion
_:108	SOBF CB fail.#:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	no
_:102	SOBF CB fail.#:Threshold phase current	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 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
_:101	SOBF CB fail.#:Threshold sensitive	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:109	SOBF CB fail.#:Delay T1 for 3-pole retrip		0.000 s to 60.000 s	0.050 s
_:110	SOBF CB fail.#:Delay T2 for 3-pole trip		0.050 s to 60.000 s	0.130 s
_:112	SOBF CB fail.#:Minimum operate time		0.00 s to 60.00 s	0.10 s
_:120	SOBF CB fail.#:3I0 criterion		• Direct release • Plausibility check	Plausibility check
_:121	SOBF CB fail.#:I2 criterion		• Direct release • Plausibility check	Plausibility check
_:122	SOBF CB fail.#:Threshold 3I0 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A

Addr.	Parameter	C	Setting Options	Default Setting
_:123	SOBF CB fail.#:Threshold I2 dir. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:124	SOBF CB fail.#:Monit. time for BI ">Start"		0.05 s to 60.00 s	15.00 s
_:125	SOBF CB fail.#:Monit.tm. f.BI ">Release"		0.05 s to 60.00 s	15.00 s

6.48.6 Information List

No.	Information	Data Class (Type)	Type
SOBF CB fail.#			
_:501	SOBF CB fail.#:>Start	SPS	I
_:502	SOBF CB fail.#:>Release	SPS	I
_:82	SOBF CB fail.#:>Block function	SPS	I
_:503	SOBF CB fail.#:>CB defect	SPS	I
_:500	SOBF CB fail.#:>Threshold sensitive	SPS	I
_:54	SOBF CB fail.#:Inactive	SPS	O
_:52	SOBF CB fail.#:Behavior	ENS	O
_:53	SOBF CB fail.#:Health	ENS	O
_:55	SOBF CB fail.#:Pickup	ACD	O
_:305	SOBF CB fail.#:Retrip T1	ACT	O
_:306	SOBF CB fail.#:Trip T2	ACT	O
_:302	SOBF CB fail.#:BI start routing miss.	SPS	O
_:304	SOBF CB fail.#:BI release rout. miss.	SPS	O
_:300	SOBF CB fail.#:Fail. BI "Start"	SPS	O
_:307	SOBF CB fail.#:Fail. no BI release	SPS	O
_:303	SOBF CB fail.#:Fail. BI "release"	SPS	O
_:315	SOBF CB fail.#:Immediate Operate	SPS	O
_:316	SOBF CB fail.#:CB failure pole	ACD	O

6.49 Circuit-Breaker Restrike Protection

6.49.1 Overview of Function

The Circuit-breaker restrike protection function:

- Monitors the circuit breaker against restriking, for example, caused by an overvoltage over the circuit breaker poles after switching off a capacitor bank
- Generates a backup operate signal in case of a circuit-breaker restriking

6.49.2 Structure of the Function

The Circuit-breaker restrike protection function is used in the Circuit-breaker function group. A maximum of 2 functions can operate simultaneously within the function group.

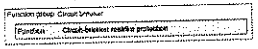

Figure 6-412 Structure/Embedding of the Function

The function logic is grouped into the parts shown in Figure 6-413. In the following chapter, these basic parts are described in detail.

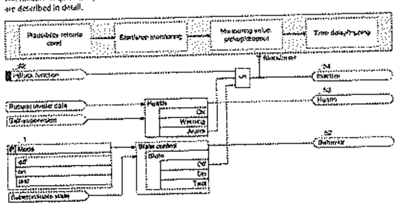

Figure 6-413 Logic Overview of the Function

6.49.3 Function Description

Plausibility Release

The function Circuit-breaker restrike protection issues a trip command to a superordinated circuit breaker, usually the infeed circuit breaker of a busbar. Overfunction of this protection can cause extreme problems for the whole application.

The logic of plausibility release strongly reduces the risk of a false start of the function by adding an extra release criteria for a function start.

Each criterion can be switched on or off individually.

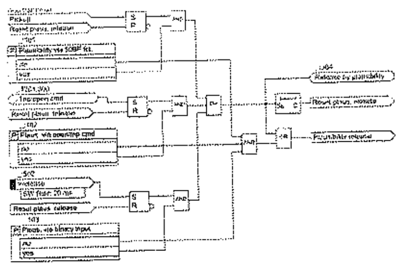

Figure 6-414 Logic Diagram for the Plausibility Release of the Circuit-Breaker Restrike Protection

The plausibility release logic checks the following conditions:

- When the parameter Plausibility via SOBF fct. is set to yes, the pickup signal of the Circuit-breaker failure protection is monitored. The plausibility release is given if the Circuit-breaker failure protection has picked up.
- When the parameter Plaus. via open/trip cmd is set to yes, the trip/open command is monitored. The plausibility release is given if the trip/open command has been generated.
- When the parameter Plaus. via binary input is set to yes, the >release signal is monitored. The plausibility release is given if the >release signal has been received.

If one of the conditions is fulfilled, the plausibility release is given for 5 s. The 5-s timer ensures that the release criterion and start condition relate to the same circuit-breaker opening/tripping process.

If all the 3 plausibility settings are set to no, the start/stop monitoring logic considers the release as fulfilled.

For safety reasons, the input signal >release has a preset software filtering time of 20 ms.

Start/Stop Monitoring

Via the start/stop monitoring logic, the monitoring duration of the current signal regarding restriking is determined.

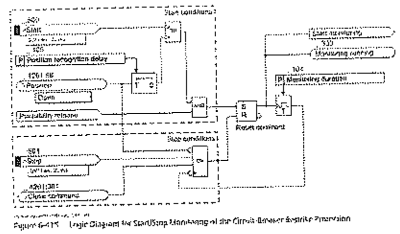

Figure 6-415 Logic Diagram for Start/Stop Monitoring of the Circuit-Breaker Restrike Protection

The monitoring is started if one of the following conditions is met:

- The circuit-breaker position is detected as open via the circuit-breaker auxiliary contacts during the time set with the parameter Position recognition delay.
  The Position recognition delay time is used for safety means to ensure that the circuit breaker is definitely open when the monitoring starts. This parameter allows to adapt this start criterion to all kinds of auxiliary-contact configurations.
- The binary input signal >Start is activated.

For safety reasons, the input signal has a preset software filtering time of 20 ms.

In addition to the active start criterion, the plausibility release (refer to the Plausibility Release, Page 1105) must be present to start the monitoring duration.

With the fulfilled start condition, the Monitoring duration timer is started. This timer defines how long the current signal is monitored regarding restriking. If the time expires, the monitoring is terminated.

The monitoring is also terminated immediately if one of the following conditions is met:

- The circuit-breaker position is detected no longer as open.
- A close command is given by the device.
- The binary input signal >Stop is activated.
  For safety reasons, the input signal has a preset software filtering time of 20 ms.

Measuring Value, Pickup/Dropout

During the Monitoring duration, the current signal is monitored phase-selectively regarding restriking.

As a measuring value, the fundamental component of the current is used.

- On one hand, current peaks are damped but still detected reliably by the fundamental-component value.
- On the other hand, a DC (Direct Current) component is suppressed. A DC component can occur after switching off the circuit breaker.

Thus, the fundamental-component value is a good choice for a reliable restrike detection.

If any phase current exceeds the set current threshold value, the function picks up. The coming pickup indicates the first restrike current pulse. With the pickup, the operate delay timers are started, see also the following description Delay/Tripping, Page 1108.

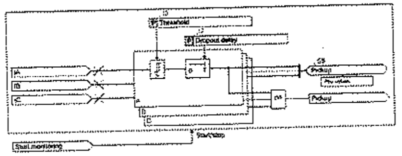

Figure 6-416 Logic Diagram for Measuring Value, Pickup/Dropout of the Circuit-Breaker Restrike Protection

If restriking occurs, the current signal drops below the current threshold if the time between restrike pulses is long enough. In this case, the operate delay must not be reset. During the dropout delay, the pickup is extended to ensure that the operate delay timers are not reset. However, if the dropout delay time expires (no new current peak occurred), the function drops out and the operate delay timers are reset.

Delay/Tripping

In the first step, tripping of the local circuit breaker can be repeated. Tripping is repeated after expiration of the settable delay T1. The retrip on the local circuit breaker is as a safety mechanism as well. In the event of a wrong start and pickup, only the local circuit breaker is opened instead of the superordinated circuit breaker.

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

If time delay T2 expires, circuit-breaker restriking takes place and the backup-tripping signal Trip T2 is generated.

If the >CB defect input signal is valid, any repetition of the trip signal is suppressed and the backup tripping signal Trip T2 is generated immediately (without delay). For safety reasons, a default software filter time of 20 ms is preset (configurable in DIGSI) for the binary input signal >CB defect.

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

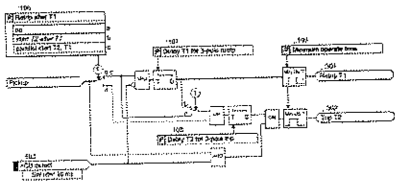

Figure 6-417 Logic Diagram for Delay/Tripping of the Circuit-Breaker Restrike Protection

6.49.4 Application and Setting Notes

Parameter: Switch On or Off Additional Plausibility Release Criteria

- Default setting (_:101) Plausibility via SOBF fct. = no
- Default setting (_:102) Plaus. via open/trip cmd = no
- Default setting (_:103) Plaus. via binary input = no

When using the plausibility release, the start condition and the release condition instead of only the start condition must be present to start the current monitoring regarding restriking. Since the current threshold value is set below the operating current, a false start would directly cause tripping. Thus, the plausibility release strongly reduces the risk that a falsely given start criterion leads to a wrong tripping of the superordinated circuit breaker.

3 different release criteria are available. You can use one or more than one or none of them. The selection depends on the application.

> **NOTE**
> When using release criteria, it must be ensured that the criteria are given under all the conditions where the Circuit-breaker restrike protection shall be started. If you choose no release criteria, the release is permanently given.

- Open/trip command by the device

Use this criterion in case that all control or trip commands are given by the protection device.

> **NOTE**
> Opening the circuit breaker manually without using the device will not release the start of the Circuit-breaker restrike protection.

- Pickup of the Circuit-breaker failure protection

Use this criterion if the Circuit-breaker restrike protection should only be started in case that the Circuit-breaker failure protection was started (picked up) before.

> **NOTE**
> Opening the circuit breaker by control or manually will not trigger the circuit breaker failure protection. Consequently, the Circuit-breaker restrike protection cannot be released either.

- Binary input signal

Use this option if neither of the above 2 release criteria fit the application and you want to define your own release criterion.

Input signals: >Start, >release, >Stop

Input Signals	Description
>Start	This input signal allows to start the monitoring, for example, via protection commands from a master (by use of a CFC chart) or by other specific conditions.
>release	This input signal allows to define specific release conditions by use of a CFC chart. Also refer to Parameter: Switch On or Off Additional Plausibility Release Criteria, Page 1109.
>Stop	This input signal allows to stop the monitoring, for example, via primary commands from a master (by use of a CFC chart) or by other specific conditions.

The input signals >Start, >release, and >Stop have a filtering time of 20 ms as default setting. If a transient spurious signal to the binary inputs is expected due to the design of the external binary-input control circuits and environmental conditions, the filtering time can be extended.

Parameter: Position recognition delay

- Default setting (_:105) Position recognition delay = 0.02 s

With the parameter Position recognition delay, you define how long the circuit breaker must be detected as open (via the circuit-breaker auxiliary contacts) before the monitoring time is started. This definition is a safety feature to ensure that the monitoring is not started too early, for example, in case that due to a non-standard auxiliary-contacts configuration, the circuit breaker is already detected as open while current flow is still present.

The setting depends on the circuit breaker auxiliary-contacts configuration. If it can be ensured that the auxiliary contacts announce the circuit breaker as open after the current flow is interrupted, the time can be set to zero.

Parameter: Monitoring duration

- Default setting (_:104) Monitoring duration = 220.00 s

With the parameter Monitoring duration, you define how long the current signal is monitored regarding restriking after the circuit breaker has been opened.

With ongoing discharging of the capacitor bank, the probability of restriking is decreasing. There is no need to set the monitoring time longer than the discharging time. Siemens recommends setting the monitoring time in the range of 0.5 * discharging time to 1 * discharging time.

Parameter: Threshold

- Default setting (_:3) Threshold = 0.250 A

After opening of the circuit breaker, the phase currents are compared with the threshold value. If no restriking takes place, the current is zero. Consequently, the threshold for detecting restriking can be set much smaller than the operating current. A typical value is 25 % of the operating current.

With a threshold below the operating current, a falsely given start directly causes tripping. For minimizing this risk, Siemens recommends applying a release criterion additionally. Refer to Parameter: Switch On or Off Additional Plausibility Release Criteria, Page 1109.

Parameter: Dropout delay

- Default setting (_:7) Dropout delay = 0.05 s

The parameter Dropout delay ensures that a short dropping below the current threshold does not cause the operate delay timers to be reset.

Since restriking is normally a periodical effect, the dropout delay can be set to a rather small time. Siemens recommends applying the default value of 50 ms.

Input signal: >CB defect

The input signal >CB defect has a preset filtering time of 20 ms. The filtering time prevents the input signal from becoming effective in the case of a transient activation of the physical binary input, which can be caused by the necessary change when the circuit breaker opens.

This time can be set to 0 if such a transient response of the physical binary input can be excluded due to the circuit-breaker design.

Parameter: Retrip after T1

- Default setting (_:106) Retrip after T1 = start T2 after T1

Parameter Value	Description
start T2 after T1	The retrip on the local circuit breaker is a safety mechanism to avoid false tripping of the superordinate circuit breaker. With generating a retrip, only the local circuit breaker is tripped. In the event of a false start, afterwards the Circuit-breaker restrike protection function drops out during the T2 delay time. Siemens recommends applying a retrip on the local circuit breaker. Siemens also recommends applying the parameter value start T2 after T1. The parameter value provides a clear chronological separation of the processes for trip repeat and backup tripping. Remember that the overall fault-clearance time in case of circuit-breaker restriking is the sum of T1 and T2.
no	No retrip is given.
parallel start T2, T1	As an alternative to the setting parallel start T2, T1 the customer can start T2 and T1 in parallel.

Parameter: Delay T1 for 3-pole retrip

- Default setting (_:101) Delay T1 for 3-pole retrip = 0.00 s

The parameter is visible only when the parameter Retrip after T1 is set to start T2 after T1 or parallel start T2, T1.

The retrip on the local circuit breaker is as a safety mechanism to avoid false tripping of the superordinated circuit breaker. In the event of a false start, only the local circuit breaker is tripped by the retrip. Afterwards the Circuit-breaker restrike protection function will drop out during the T2 delay time.

Siemens recommends applying a retrip on the local circuit breaker. Since the retrip is a safety mechanism, it can be given without a delay time. Siemens recommends setting the delay time to 0 s.

Parameter: Delay T2 for 3-pole trip

- Default setting (_:110) Delay T2 for 3-pole trip = 0.15 s

This parameter defines the duration of restriking after the backup tripping is sent. The following should be considered:

- When using the retrip functionality, this delay time must ensure a safe function dropout after giving the retrip on the local circuit breaker.

Siemens recommends applying a delay time of 150 ms which is the default setting.

Parameter: Minimum operate time

- Default setting (_:109) Minimum operate time = 0.15 s

The Minimum operate time parameter is used to set the minimum duration for the trip command of the function.

⚠ **CAUTION**

Do not set a time that is too short.

If you set a time that is too short, there is a danger (dropout of the function without the current-flow criterion) that the device contacts interrupt the control circuit. If this happens, the device contacts burn out.

- Set a duration that is long enough to ensure that the circuit breaker reliably reaches its final position (open) after a control operation.

Output signal: *Retrip T2*

The output signal Retrip T1 must be routed to a binary output.

If only one control circuit is available for the local circuit breaker, the output signal must be routed to the binary output to which the general circuit breaker trip command (Command Trip/Open) is routed.

If a second control circuit is present, the Retrip T2 output signal can be routed to the associated binary output.

Output signal: *Trip T2*

In order to trip the adjacent circuit breakers, the backup tripping indication Trip T2 must be routed to a binary output and if necessary, to an interface (intertripping to the opposite end). Thus, the circuit breaker on the opposite end can be tripped without delay.

6.49.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Restrike prt.#				
_:1	Restrike prt.#:Mode		• off • on • test	off
_:101	Restrike prt.#:Plausibility via 50BF fct.		• no • yes	no
_:102	Restrike prt.#:Plaus. via open/trip cmd		• no • yes	no
_:103	Restrike prt.#:Plaus. via binary input		• no • yes	no
_:106	Restrike prt.#:Retrip after T1		• no • start T2 after T1 • parallel start T2, T1	start T2 after T1
_:104	Restrike prt.#:Monitoring duration		1.00 s to 600.00 s	200.00 s
_:105	Restrike prt.#:Pos.Ident. recognition delay		0.00 s to 60.00 s	0.02 s
_:3	Restrike prt.#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.250 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.250 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.250 A
_:7	Restrike prt.#:Dropout delay		0.00 s to 60.00 s	0.05 s
_:107	Restrike prt.#:Delay T1 for 3-pole retrip		0.00 s to 60.00 s	0.00 s
_:108	Restrike prt.#:Delay T2 for 3-pole trip		0.05 s to 60.00 s	0.15 s
_:109	Restrike prt.#:Minimum operate time		0.00 s to 60.00 s	0.15 s

6.49.6 Information List

No.	Information	Data Class (Type)	Type
Restrike prt.#			
_:500	Restrike prt.#:>Start	SPS	I
_:501	Restrike prt.#:>Stop	SPS	I
_:502	Restrike prt.#:>closed	SPS	I
_:82	Restrike prt.#:>Block function	SPS	I
_:503	Restrike prt.#:>CB defect	SPS	I
_:54	Restrike prt.#:Inactive	SPS	O
_:52	Restrike prt.#:Behavior	ENS	O
_:53	Restrike prt.#:Health	ENS	O
_:304	Restrike prt.#:Release by plausibility	SPS	O
_:306	Restrike prt.#:Monitoring running	SPS	O
_:55	Restrike prt.#:Pickup	[illegible]	O
_:301	Restrike prt.#:Retrip T1	ACT	O
_:302	Restrike prt.#:Trip T2	ACT	O

6.50 Arc Protection

6.50.1 Overview of Function

The function Arc protection:

- Detects arcs in air-insulated switchgear parts without delay and in a fail-safe way
- Limits system damage through instantaneous high-speed tripping
- Protect systems from thermal overload
- Increases safety of personnel
- Trips in a 3-pole way
- Is suitable for use in all voltage levels

6.50.2 Structure of the Function

The Arc protection function can be added to function groups that provide current measured values.

The Arc protection function consists of the following blocks:

- General
- 3 stages
- Output logic 3-phase

The Arc protection function is preconfigured with 3 stages. A maximum of 12 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The following figure shows the basic structure of the Arc protection function.

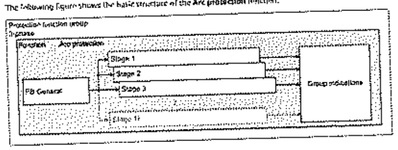

Figure 6-418 Structure/Embedding of the Arc Protection Function

6.50.3 Function Description

General Logic of the Function Block

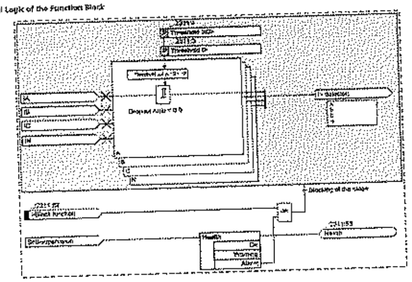

Figure 6-419 General Logic Diagram of the Function Block

Logic of the Stage

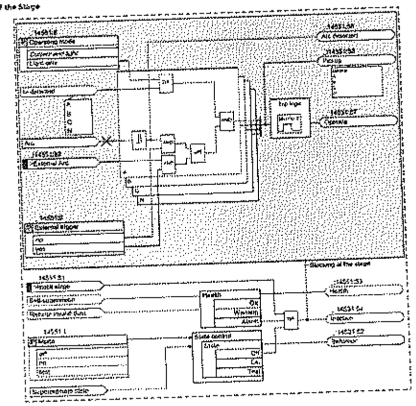

Figure 6-420 Logic Diagram of the Stage

The Arc protection function uses a locally connected optical arc sensor or an external trip initiation by other devices in order to detect arcs.

NOTE

Install the arc sensors inside the switchgear in such a way that they are not hidden behind other system components!

Shadowing of the arc sensors must be avoided!

NOTE

Once an optical sensor has detected an arc, you must replace the affected optical sensor!

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Within the Arc protection function, you can use a fast current-flow criterion as an additional release criterion. The parameters for the current-flow criterion can be found in the General block. For each stage, you can select individually whether the current-flow criterion must be evaluated as well.

Method of Measurement, Current-Flow Criterion

The current-flow criterion works with 2 different methods of measurement:

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A direct current component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurands:
  If the current exceeds the threshold value set by the current amount : 2 · √2 · threshold value, the stage uses additional unfiltered measurands. Thus, very short operate times are possible.

> **NOTE**
> If using the current-flow criterion in addition to the light, prevents a potential overfunction caused by the suddenly occurring light signal.
> If you use the current-flow criterion, arcs are typically detected in 4 ms.

Self Monitoring

The Arc protection function uses a self-monitoring circuit. This circuit monitors the optical arc sensors and the fiber-optic cables. The arc-protection module uses the fiber-optic cable to send a cyclic test signal (light) to the arc sensors. If the channel is operating properly, the test signal is sent back to the arc-protection module. If the test signal is not returned to the arc-protection module, the indication *Channel # Sensor failure* is generated.

If the self-monitoring function detects a fault, the indication *Health* is set to *Alarm* and the stage/function is blocked.

6.50.4 Application and Setting Notes – General Settings

Go to General under the function Arc protection and set the following parameters. The setting values apply to all stages.

Parameter: Threshold I>

- Default setting (_:2311:3) Threshold I> = 2.000 A

Use the parameter Threshold I> to define the trigger threshold of the phase currents. The Threshold I> is relevant for the current-flow criterion of the arc protection function.

Set the Threshold I> of the function Arc protection in such a manner that the RMS value of the inrush current does not exceed the Threshold I> when activating the local circuit breaker.

For more information about how to calculate the setting value, refer to 6.16.4.2 Application and Setting Notes.

Parameter: Threshold 3I0>

- Default setting (_:2311:4) Threshold 3I0> = 1.000 A

Use the parameter Threshold 3I0> to determine the tripping threshold for the zero-sequence current. The Threshold 3I0> is relevant for the current-flow criterion of the Arc protection function.

Set the Threshold 3I0> of the function Arc protection in such a manner that the RMS value of the inrush current does not exceed the Threshold 3I0> when activating the local circuit breaker.

For more information about how to calculate the setting value, refer to 6.17.4.2 Application and Setting Notes.

> **NOTE**
> If you set the parameter CT connection = 3-phase, 2 primary CT for the 3-phase current measuring point, the parameter Threshold 3I0> has no effect.

6.50.5 Application and Setting Notes for the Stage

Parameter: External trip initiation

- Default setting (_:14551:9) External trip initiation = no

Use the parameter External trip initiation to set whether an external input signal is used to trigger the stage.

Parameter Value	Description
no	The stage does not operate with an external input signal.
yes	The stage operates with an external input signal. If the stage operates with an external input signal, the binary input signal >External Arc must be routed in the DIGSI 5 information routing. In this setting option, the binary input signal >External Arc is only visible in the DIGSI 5 information routing. Note: When working with external trip initiation, do not select a channel. If an additional channel is selected with this setting value, DIGSI 5 will signal an inconsistency.

Parameter: Operating mode

- Default setting (_:14551:8) Operating mode = Current and light

Use the parameter Operating mode to define the basic functionality of the stage.

Parameter Value	Description
Current and light	The stage operates with the input variables current and light. The current-flow criterion ensures that the light signal originates from an arc. Siemens recommends using this setting.
Light only	This stage operates only with the input signal light and is triggered even if current is not measured. This operating mode can cause a overfunction if light is detected suddenly. Use this setting value only if the effect caused by external light signals is impossible.

Parameter: Sensor

- Default setting (_:14551:11) Sensor = Point sensor

Use the parameter Sensor to set which sensor type is connected to the device.

Parameter Value	Description
Point sensor	A point sensor is connected to the device.
Line sensor	A line sensor is connected to the device.
Custom	If you select this setting option, the parameter Threshold Light is visible. Siemens recommends the default setting values Point sensor or Line sensor. This allows arcs to be detected reliably regardless of diffused light.

Parameter: Threshold Light

- Default setting (_:14551:7) Threshold Light = -20.00 dB

Use the parameter Threshold Light to set the light sensitivity. If you set the Threshold Light to a smaller value, the sensitivity increases. If you set the Threshold Light to a higher value, the sensitivity decreases. If the sensors even pick up in case of a switching arc of the circuit breaker, set the Threshold Light parameter to a higher value.

Siemens recommends the default settings for point or line sensors.

Set the parameter Threshold Light manually only if you have special default settings for light sensitivity.

Parameter: Channel

- Default setting (_:14551:10) Channel = No channel is selected

Use the parameter Channel to select which sensor channel the stage uses.

If the Arc protection function has several stages, a different channel must be selected for each stage.

For parameter Channel, the selection texts are identical to the name of the arc-protection module and its channels.

6.50.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:3	General:Threshold I>	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A
_:2311:4	General:Threshold 3I0>	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
Stage 1				
_:14551:1	Stage 1:Mode		• off • on • test	off
_:14551:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:14551:9	Stage 1:External trip initiation		• no • yes	no
_:14551:8	Stage 1:Operating mode		• Light only • Current and light	Current and light
_:14551:11	Stage 1:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14551:7	Stage 1:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14551:10	Stage 1:Channel		Setting options depend on configuration	

Addr.	Parameter	C	Setting Options	Default Setting
Stage 2				
_:14552:1	Stage 2:Mode		• off • on • test	off
_:14552:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:14552:9	Stage 2:External trip initiation		• no • yes	no
_:14552:8	Stage 2:Operating mode		• Light only • Current and light	Current and light
_:14552:11	Stage 2:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14552:7	Stage 2:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14552:10	Stage 2:Channel		Setting options depend on configuration	
Stage 3				
_:14553:1	Stage 3:Mode		• off • on • test	off
_:14553:2	Stage 3:Operate & flt.rec. blocked		• no • yes	no
_:14553:9	Stage 3:External trip initiation		• no • yes	no
_:14553:8	Stage 3:Operating mode		• Light only • Current and light	Current and light
_:14553:11	Stage 3:Sensor		• Point sensor • Line sensor • Custom	Point sensor
_:14553:7	Stage 3:Threshold Light		-34.00 dB to -10.00 dB	-20.00 dB
_:14553:10	Stage 3:Channel		Setting options depend on configuration	

6.50.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:14551:81	Stage 1:>Block stage	SPS	I
_:14551:67	Stage 1:>External Arc	SPS	I
_:14551:54	Stage 1:Inactive	SPS	O
_:14551:52	Stage 1:Behavior	ENS	O
_:14551:53	Stage 1:Health	ENS	O
_:14551:58	Stage 1:Arc detected	SPS	O
_:14551:55	Stage 1:Pickup	ACD	O
_:14551:57	Stage 1:Operate	ACT	O
Stage 2			
_:14552:81	Stage 2:>Block stage	SPS	I
_:14552:67	Stage 2:>External Arc	SPS	I
_:14552:54	Stage 2:Inactive	SPS	O
_:14552:52	Stage 2:Behavior	ENS	O
_:14552:53	Stage 2:Health	ENS	O
_:14552:58	Stage 2:Arc detected	SPS	O
_:14552:55	Stage 2:Pickup	ACD	O
_:14552:57	Stage 2:Operate	ACT	O
Stage 3			
_:14553:81	Stage 3:>Block stage	SPS	I
_:14553:67	Stage 3:>External Arc	SPS	I
_:14553:54	Stage 3:Inactive	SPS	O
_:14553:52	Stage 3:Behavior	ENS	O
_:14553:53	Stage 3:Health	ENS	O
_:14553:58	Stage 3:Arc detected	SPS	O
_:14553:55	Stage 3:Pickup	ACD	O
_:14553:57	Stage 3:Operate	ACT	O

Informationen der Selbstüberwachung vom Lichtbogenschutz-Modul

No.	Information	Data Class (Type)	Type
Channel #			
_:307	Channel # Sensor failure	SPS	O

6.50.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only

6.50.8.1 Description

Overview

The example describes the Arc protection function in a medium-voltage switchgear with one infeed and 2 feeders. The Arc protection function operates with the Operating mode = Light only.

The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function

The following figure shows the arrangement and the connection of the optical point sensors:

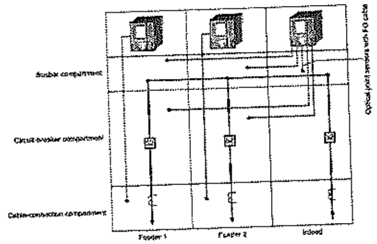

Figure 6-421 Layout and Connection of the Optical Point Sensors (Operating Mode = Light only)

For this example, the following is assumed:

- The circuit breaker of the infeed must be switched off. This ensures that the arcs in the busbar compartments of the infeed and the feeders or in the circuit-breaker compartment of the feeders are off. Install the optical point sensors in the busbar compartments (BB compartment) of the infeed and feeders. Install additional optical point sensors in the circuit-breaker compartment (CB compartment) of the feeders. Connect all optical point sensors to the protection device of the infeed.
- The optical point sensors in the cable connection compartment of the feeders detect arcs in this compartment. Install one optical point sensor in the cable connection compartment of the feeders and connect it to the protection device of the feeder. This allows for the selective clearing of arcs inside the cable-connection compartment.
  Due to the pressure waves that occur during the formation of an arc, partitions can deform and cause undesirable light influences in adjacent compartments. This can result in a non-selective tripping.
- If there is an arc in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must switch off.

> **NOTE**
> If the Arc protection function operates in Operating mode = Light only, the effects of external light can result in non-selective tripping.

> **NOTE**
> It must be considered that the number of arc-protection modules connected to the device depends on the hardware configuration of the device.
> When using modular devices, a maximum of 15 sensors can be connected. If using non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

6.50.8.2 Application and Setting Notes

General Notes

- Connect one optical point sensor from the cable-connection compartment in feeder 1 to the protection device in feeder 1. Arcs in the cable-connection compartment are cleared selectively by the circuit breaker in feeder 1.
- Connect one optical point sensor from the cable-connection compartment in feeder 2 to the protection device in feeder 2. Arcs in the cable-connection are cleared selectively by the circuit breaker in feeder 2.
- Connect optical point sensors from all busbar compartments and all circuit-breaker compartments of feeders 1 and 2 to the protection device in the infeed. Arcs in these compartments are detected and cleared by the device in the infeed.

Setting Notes for the Protection Device in Feeder 1

The Arc protection function operates with one stage.
Set the parameters of the stage as follows:

- Parameter: Operating mode = Light only
- Parameter: Sensor = Point sensor
- Parameter: External trip initiation = no
- Parameter: Channel = Arc mod. 1 channel 3

The parameters in block General are not relevant since the Operating mode = Light only.

Setting Notes for the Protection Device in Feeder 2

The Arc protection function operates with one stage.
Set the parameters of the stage as follows:

- Parameter: Operating mode = Light only
- Parameter: Sensor = Point sensor
- Parameter: External trip initiation = no
- Parameter: Channel = Arc mod. 1 channel 3

The parameters in block General are not relevant since the Operating mode = Light only.

Setting Notes for the Protection Device in the Infeed

The Arc protection function operates with 5 stages.
Set the parameters of the stages as follows:

- Parameter: Operating mode = Light only (applies to all stages)
- Parameter: Sensor = Point sensor (applies to all stages)
- Parameter: External trip initiation = no (applies to all stages)
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Busbar compartment supervision in feeder 1
  Parameter: Channel = Arc mod. 1 channel 2 (Stage 2) → Circuit breaker compartment supervision in feeder 1
  Parameter: Channel = Arc mod. 1 channel 3 (Stage 3) → Busbar compartment supervision in feeder 2
  Parameter: Channel = Arc mod. 2 channel 1 (Stage 4) → Circuit-breaker compartment supervision in feeder 2
  Parameter: Channel = Arc mod. 2 channel 2 (Stage 5) → Busbar compartment supervision in the infeed

The parameters in block General are not relevant since the Operating mode = Light only.

6.50.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current

6.50.9.1 Description

Overview

The example describes the Arc protection function in a medium-voltage switchgear with one infeed and 2 feeders. The Arc protection function operates with the Operating mode = Current and light. In the example, all arcs are detected by the protection device in the infeed.

The following items are considered in the example:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about selected parameters in the stages of the function

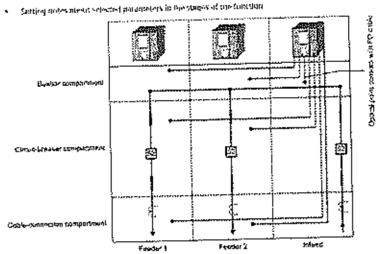

Figure 6-422 Layout and Connection of the Optical Point Sensors (Operating Mode = Current and Light)

For this example, the following is assumed:

- The current-flow criterion offers additional security to prevent unwanted tripping caused by sudden light influences.
  Depending on the arc location in the cable-connection compartment of the feeder, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the feeder, the current will therefore be evaluated in the infeed.
- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders as well as the busbar compartment of the infeed. Connect the optical point sensors to the protection device in the infeed.
- The protection device in the infeed clears all arcs in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of feeder 1 and 2. Furthermore, the protection device clears arcs in the busbar compartment of the infeed.

- If the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders, or in the busbar compartment of the infeed detect an arc, the protection device in the infeed evaluates the current as well.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device must trip.

NOTE

If the Arc protection function operates with the Operating mode = Current and light, the additional current-flow criterion prevents unwanted tripping caused by external light influences.

NOTE

This application example requires the connection of several optical point sensors to a single protection device. It must be considered that the number of arc-protection modules that are connected to the device depends on the hardware configuration of the device.
When using modular devices, a maximum of 15 sensors can be connected. If you use non-modular devices, a maximum of 6 sensors (3 sensors per module) can be connected.

6.50.9.2 Application and Setting Notes

General Notes

- Connect the optical point sensors from the busbar compartment, the circuit breaker compartment, and the cable-connection compartment of feeders 1 and 2 to the protection device in the infeed. Arcs in the busbar compartment, the circuit-breaker compartment and the cable-connection compartment of feeders 1 and 2 are detected and cleared by the device in the infeed.
- Connect an optical point sensor from the busbar compartment in the infeed to the protection device in the infeed. Arcs in the busbar compartment of the infeed are cleared selectively by the circuit breaker in the infeed.

Setting Notes for the Protection Device in the Infeed

The Arc protection function operates with 7 stages.
Set the parameters of the stages as follows:

- Parameter: Operating mode = Current and light (applies to all stages)
- Parameter: Sensor = Point sensor (applies to all stages)
- Parameter: External trip initiation = no (applies to all stages)
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Busbar compartment supervision in feeder 1
  Parameter: Channel = Arc mod. 1 channel 2 (Stage 2) → Circuit-breaker compartment supervision in feeder 1
  Parameter: Channel = Arc mod. 1 channel 3 (Stage 3) → Cable-connection compartment supervision in feeder 1
  Parameter: Channel = Arc mod. 2 channel 1 (Stage 4) → Busbar compartment supervision in feeder 2
  Parameter: Channel = Arc mod. 2 channel 2 (Stage 5) → Circuit breaker compartment supervision in feeder 2
  Parameter: Channel = Arc mod. 2 channel 3 (Stage 6) → Cable-connection compartment supervision in feeder 2
  Parameter: Channel = Arc mod. 3 channel 1 (Stage 7) → Busbar compartment supervision in the infeed

You can find more information about the settings of the parameters Threshold I> and Threshold 3I0> in chapter 6.50.4 Application and Setting Notes – General Settings.

6.50.10 Application Example for Arc Protection with Point Sensors via External Trip Initiation

6.50.10.1 Description

Overview

The example describes the Arc protection function in a medium-voltage switchgear with one infeed and 2 feeders. The stages of the Arc protection function are triggered by External trip initiation.

The following items are considered in the example below:

- Positioning the optical point sensors in the switchgear
- Connecting the optical point sensors to the protection devices in the feeders and the infeed
- Number of necessary stages of the functions in the protection devices of the feeders and the infeed
- Setting notes about the selected parameters in the stages of the function

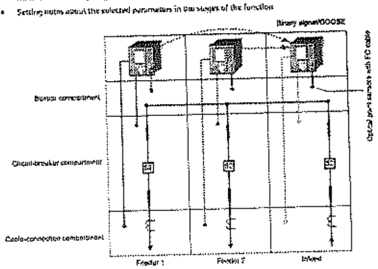

Figure 6-423 Arc Protection with External Trip Initiation

For this example, the following is assumed:

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeder and the infeed. Connect the optical point sensors to the respective protection device in the feeder and infeed.
- If the optical point sensors detect an arc in the busbar compartment, the circuit-breaker compartment, or the cable-connection compartment of the feeder, the Arc detected indication is sent via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device in the infeed. Then, the protection device in the infeed evaluates the current as well. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed clears the malfunction.
  You can find detailed information in chapter 6.50.10.2 Application and Setting Notes.

- Alternatively, arcs in the cable-connection compartment of the feeders can be cleared selectively by the protection device of the affected feeder. To do this, the pickup indication from the infeed unit must be sent back to the appropriate protection device in the feeder.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device trips.

NOTE

If the Arc protection function operates via the External trip initiation, only 3 optical point sensors are required per feeder protection device in order to detect the arcs (only one arc-protection module).
The signals from the feeder protection devices are sent via binary inputs/outputs, a protection interface or IEC 61850 GOOSE to the protection device of the infeed and processed.
The number of GOOSE messages is not limited. Therefore, the number of feeders is not limited, and the protection of complex systems is feasible.
Siemens recommends using the Arc protection function with external trip initiation.

6.50.10.2 Application and Setting Notes

General Notes:

- Install the optical point sensors in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders and the infeed to the respective protection devices.
- Arcs in the busbar compartment, the circuit-breaker compartment, and the cable-connection compartment of the feeders must be cleared by the protection device in the infeed. To do this, the protection devices in the feeder device must send the indication Arc detected to the infeed device. Use the binary inputs/outputs, a protection interface, or IEC 61850 GOOSE.
- The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed clears the malfunction.
  Connect the signals over 6 stages, using the external trip initiation or in CFC charts.

Setting Notes for the Protection Device in Feeder 1

The Arc protection function operates with 3 stages.
Set the parameters of the stages as follows:

- Parameter: Operating mode = Light only (applies to all stages)
- Parameter: Sensor = Point sensor (applies to all stages)
- Parameter: External trip initiation = no (applies to all stages)
- Parameter: Operate & flt.rec. blocked = yes (applies to all stages)
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Busbar compartment supervision in feeder 1
  Parameter: Channel = Arc mod. 1 channel 2 (Stage 2) → Circuit-breaker compartment supervision in feeder 1
  Parameter: Channel = Arc mod. 1 channel 3 (Stage 3) → Cable connection compartment supervision in feeder 1

Setting Notes for the Protection Device in Feeder 2

The Arc protection function operates with 3 stages.
Set the parameters of the stages as follows:

- Parameter: Operating mode = Light only (applies to all stages)
- Parameter: Sensor = Point sensor (applies to all stages)

- Parameter: External trip initiation = no (applies to all stages)
- Parameter: Operate & flt.rec. blocked = yes (applies to all stages)
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Busbar compartment supervision in feeder 2
  Parameter: Channel = Arc mod. 1 channel 2 (Stage 2) → Circuit-breaker compartment supervision in feeder 2
  Parameter: Channel = Arc mod. 1 channel 3 (Stage 3) → Cable-connection compartment supervision in feeder 2

Setting Notes for the Protection Device in the Infeed

The Arc protection function operates with 9 stages.

Stage 1 (busbar compartment supervision):

- Parameter: Operate & flt.rec. blocked = no
  If an arc is detected in the busbar compartment of the infeed and the thresholds Threshold I> or Threshold 3I0> are exceeded, an operate indication is generated immediately.
- Parameter: Channel = Arc mod. 1 channel 1
- Parameter: Operating mode = Current and light
- Parameter: Sensor = Point sensor
- Parameter: External trip initiation = no

Stage 2 (circuit-breaker compartment supervision):

- Parameter: Operate & flt.rec. blocked = yes
  If an arc is detected in the circuit-breaker compartment of the infeed (light-gray point sensors in Figure 6-423), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
- Parameter: Channel = Arc mod. 1 channel 2
- Parameter: Operating mode = Current and light
- Parameter: Sensor = Point sensor
- Parameter: External trip initiation = no

Stage 3 (cable-connection compartment supervision):

- Parameter: Operate & flt.rec. blocked = yes
  If an arc is detected in the cable-connection compartment of the infeed (light-gray point sensors in Figure 6-423), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
  Depending where the arc is generated in the cable-connection compartment of the infeed, it is not always possible to measure the current. If an arc is detected in the cable-connection compartment of the infeed, the current must be evaluated by the superordinate protection device.
- Parameter: Channel = Arc mod. 1 channel 3
- Parameter: Operating mode = Light only
- Parameter: Sensor = Point sensor
- Parameter: External trip initiation = no

Stage 4 to 9 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = no
- Parameter: Operating mode = Current and light

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- Parameter: External trip initiation = yes
  If an arc is detected in the busbar compartment, the circuit-breaker compartment, or the cable-connection compartment of the feeder, the feeder device sends the indication Arc detected to the infeed device. Only if the indication in the infeed device Arc detected is connected with the signal >External Arc, an external trip initiation via these stages is effective.
  The protection device in the infeed evaluates the current. If the measured current exceeds the Threshold I> and/or Threshold 3I0> threshold values, the protection device in the infeed clears the arc.

6.50.10.3 Application and Setting Notes for Variant 2 (with Feedback to Feeder Protection Devices)

General Notes:

- Connect the optical sensors in the busbar compartment, the CB compartment, and the cable-connection compartment of the feeder 1 and 2 and the infeed to the respective protection devices.
- Arcs in the busbar compartment and in the CB compartment of the feeders must be cleared by the protection device in the infeed. To do this, the protection devices in the feeder must send the indication Arc detected to the infeed device. Use the binary inputs/outputs, a protection interface, or IEC 61850 GOOSE.
- Arcs in the cable-connection compartment of the feeder are cleared selectively. Here, the message Arc detected is sent as well via binary inputs/outputs, a protection interface, or IEC 61850 GOOSE to the protection device in the infeed.
  The protection device in the infeed evaluates the current. If the measured current exceeds the threshold values Threshold I> and/or Threshold 3I0>, the protection device in the infeed sends the pickup indication of the stage back to the protection device in the affected feeder. The protection device in the affected feeder clears the arc selectively.
  Due to the pressure wave that occurs during an arc, partitions may deform and cause undesirable light influences in adjacent compartments. This may result in a non-selective trip.

NOTE

The External trip initiation function must be instantiated in the protection devices of the feeders.

Setting Information for the Protection Device in Feeder 1

The Arc protection function operates with 4 stages.

Stage 1 to 3:

- Parameter: Operating mode = Light only
- Parameter: External trip initiation = no
- Parameter: Operate & flt.rec. blocked = yes
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Monitoring busbar compartment in feeder 1
  Parameter: Channel = Arc mod. 1 channel 2 (Stage 2) → Monitoring CB compartment in feeder 1
  Parameter: Channel = Arc mod. 1 channel 3 (Stage 3) → Monitoring cable-connection compartment in feeder 1

Stage 4 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = no
- Parameter: Operating mode = Light only

- Parameter: External trip initiation = yes
  If an arc is detected in the cable-connection compartment of the feeder, the indication Arc detected is sent to the protection device in the infeed.
  The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed picks up. The pickup indication from the protection device in the infeed is injected via this stage into the feeder protection device. This makes a selective tripping in the feeder possible.

Setting Information for the Protection Device in Feeder 2

The Arc protection function operates with 4 stages.

Stage 1 to 3:

- Parameter: Operating mode = Light only
- Parameter: External trip initiation = no
- Parameter: Operate & flt.rec. blocked = yes
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Monitoring busbar compartment in feeder 2
  Parameter: Channel = Arc mod. 1 channel 2 (Stage 2) → Monitoring CB compartment in feeder 2
  Parameter: Channel = Arc mod. 1 channel 3 (Stage 3) → Monitoring cable-connection compartment in feeder 2

Stage 4 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = no
- Parameter: Operating mode = Light only
- Parameter: External trip initiation = yes
  If an arc is detected in the cable-connection compartment of the feeder, the indication Arc detected is sent to the protection device in the infeed.
  The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed picks up. The pickup indication from the protection device in the infeed is injected via this stage into the feeder protection device. This makes a selective tripping in the feeder possible.

Setting Information for the Protection Device in the Infeed

If arcs in the cable-connection compartments of the feeder shall be switched off selectively by the protection device in the feeder, the following setting notes for the protection device in the infeed apply.

The Arc protection function operates with 9 stages.

Stage 1 (busbar-compartment monitoring):

- Parameter: Operate & flt.rec. blocked = no
  If an arc is detected in the busbar compartment of the infeed, an operate indication is generated immediately.
- Parameter: Channel = Arc mod. 1 channel 1
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = no

Stage 2 (CB compartment monitoring):

- Parameter: Operate & flt.rec. blocked = yes
  If an arc is detected in the CB compartment of the infeed (light-gray sensors in Figure 6-421), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
- Parameter: Channel = Arc mod. 1 channel 2

- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = no

Stage 3 (cable connection compartment monitoring):

- Parameter: Operate & flt.rec. blocked = yes
  If an arc is detected in the cable connection compartment of the infeed (light-gray sensors in Figure 6-421), a pickup indication is generated immediately. The arc is cleared by a superordinate protection device.
  Depending on the arc location in the cable-connection compartment of the infeed, it is not always possible to measure the current. If an arc is detected in the cable connection compartment of the infeed, the current must be evaluated by the superordinate protection device.
- Parameter: Channel = Arc mod. 1 channel 3
- Parameter: Operating mode = Light only
- Parameter: External trip initiation = no

Stage 4 to 7 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = no
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = yes

If an arc is detected in the busbar compartment or the CB compartment of the feeders, the feeder device sends the indication Arc detected to the infeed device. An external trip initiation via these stages is effective only if the indication Arc detected is connected with the signal >External Arc in the infeed device.
The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed clears the arc.

Stage 8 and 9 (External trip initiation):

- Parameter: Operate & flt.rec. blocked = yes
- Parameter: Operating mode = Current and light
- Parameter: External trip initiation = yes

If an arc is detected in the cable-connection compartment of the feeder, the feeder device sends the indication Arc detected to the infeed device. An external trip initiation via these stages is effective only if the indication Arc detected is connected with the signal >External Arc in the infeed device.
The protection device in the infeed evaluates the current. If the measured current exceeds the thresholds Threshold I> and/or Threshold 3I0>, the protection device in the infeed picks up. The pickup indication Arc detected will be sent back to the feeder protection device. This makes a selective tripping in the feeder possible.

6.51 Inrush-Current Detection

6.51.1 Overview of Functions

The function Inrush-current detection

- Recognizes an inrush process on transformers
- Generates a blocking signal for protection functions that protect the transformer (protected object) or for protection functions that are affected in undesirable ways when transformers are switched on
- Allows a sensitive setting of the protection functions

The following protection functions evaluate the blocking signal

- Overcurrent protection with a pickup value below the maximum inrush current
- Negative-sequence protection as sensitive backup protection for transformers
- Distance protection for impedance stages graded through the transformer

NOTE

The Transformer differential protection has its own inrush-current detection.
You can find more information in chapter 6.2.3.6 Differential Protection Function (ADP) under the section Inrush-Current Detection.

6.51.2 Structure of the Function

The function **Inrush current detection** is not an individual protection function. In the connection process of a transformer, it transmits a blocking signal to other protection functions. For this reason, the inrush-current detection must be in the same function group as the functions that are to be blocked.
The following figure shows the embedding of the function. The setting parameter Blk. w. inrush curr. detect. establishes the connection between inrush current detection and the functions that are to be blocked. If the parameter is set to yes, the connection is effective.
A jump detection or the threshold value exceeding of the functions to be blocked is used as trigger signal for synchronization of the internal measurement methods.
The jump detection reacts to changes in the current. The threshold value exceeding is recognized due to an internal pickup of the protection function that is to be blocked.

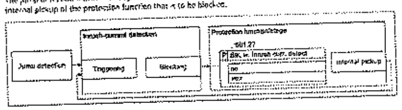

Figure 6-424 Structure/Embedding of the Function

6.51.3 Function Description

The function Inrush-current detection analyzes the trigger signal of the jump detection or the threshold-value violation of the function to be blocked in a start logic, and synchronizes the method of measurement. In order to securely detect the inrush processes, the function uses the harmonic analysis method of measurement and the CWA method (current wave shape analysis). Both methods work in parallel and link the results through a logical OR.

If you wish to work with only one process, deactivate the other method by way of the parameters Blocking with 2. harmonic or Blocking with CWA.

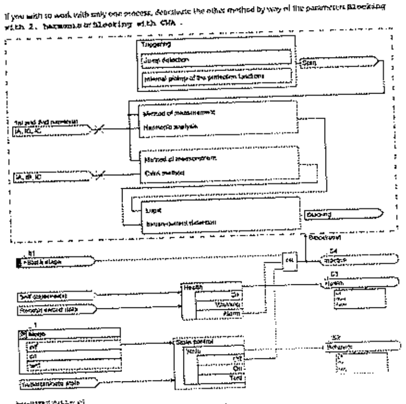

Figure 6-425 Basic Structure of the Inrush Current Detection

Harmonic Analysis

For this method of measurement, the content of the 2nd harmonic and the fundamental component (1st harmonic) are determined for each of the phase currents I_A, I_B, and I_C and the quotient $I_{2nd\ harm}/I_{1st\ harm}$ is formed from this. If this quotient exceeds the set threshold value, a phase-selective signal is issued.
If 95 % of the set threshold value is exceeded, this leads to a pickup reset (dropout ratio = 0.95).

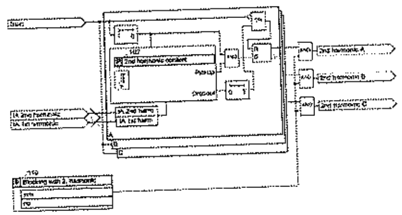

Figure 6-426 Logic of the Harmonic Analysis Function (T = 1 Period)

CWA Method (Current Wave Shape Analysis)

The CWA method executes a wave-shape analysis of the phase currents IA, IB, and IC. If all 3 phase currents show flat areas at the same point in time, the inrush-current detection signal will be issued. This signal applies for all 3 phases simultaneously. The following figure shows a typical inrush-current characteristic, with the simultaneously occurring flat areas clearly recognizable.

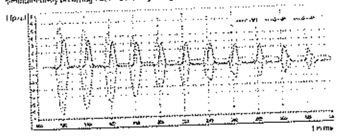

Figure 6-427 Inrush Current Characteristic

The following figure shows the logic diagram of the CWA method.
From the present fundamental-component current (1st harmonic), the threshold value for identification of the flat areas is derived via an internal factor.

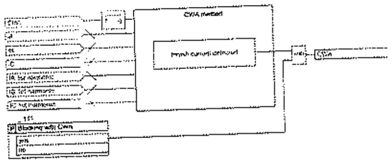

Figure 6-428 Logic of the CWA Method Function (f = 1 Period)

Logic of the Inrush-Current Detection

The following logic diagram shows the link of the 2 methods of measurement Harmonic Analysis and CWA method.

The crossblock function influences the Harmonic Analysis process. If you have set the parameter Cross-blocking to yes, you will receive in the event of threshold-value violation a blocking indication for all 3 phase currents and the measured or calculated zero-sequence current. The crossblock function works via a timer. Set parameters for the time depending on the expected duration factor via the parameter Cross-blocking time.

If the phase current exceeds the maximum permissible current Operat.-range limit Imax, the inrush current detection will be blocked.

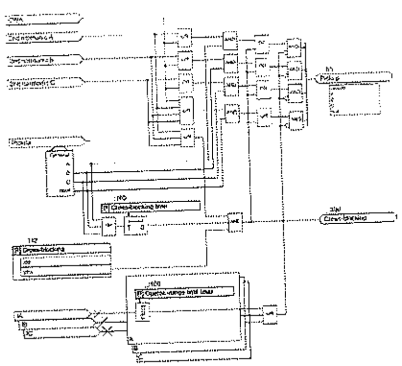

Figure 6-429 Logic Diagram of the Inrush-Current Detection

6.51.4 Application and Setting Notes

Parameter: Operat.-range limit Imax

- Recommended setting value (_:106) Operat.-range limit Imax = 7.5 A

With the parameter Operat.-range limit Imax, you can specify at which current the inrush-current detection is blocked internally. The setting value must be above the maximum inrush current of the transformer. A practicable value is 7.5 times the transformer rated current.

Parameter: Blocking with CWA

- Recommended setting value (_:111) Blocking with CWA = yes

Parameter Value	Description
yes	CWA process activated.
no	CWA process deactivated.

Parameter: Blocking with 2. harmonic

- Recommended setting value (_:110) Blocking with 2. harmonic = yes

Parameter Value	Description
yes	Harmonic analysis process activated.
no	Harmonic analysis process deactivated.

NOTE

Make sure that at least one process is activated. Siemens recommends retaining the default setting values.

Parameter: 2nd harmonic content

- Recommended setting value (_:102) 2nd harmonic content = 15 %

With the parameter 2nd harmonic content, you can specify the pickup value of the harmonic analysis function. The setting value of 15 % is practicable for most transformers.

Parameter: Cross-blocking

- Recommended setting value (_:112) Cross-blocking = no

Parameter Value	Description
no	Through the CWA process working in parallel in the inrush-current detection, the function is not activated as standard.
yes	If a subfunction of the inrush-current detection is identified in the course of the closure tests during commissioning, set the parameter Cross-blocking to yes.

Parameter: Cross-blocking time

- Default setting (_:109) Cross-blocking time = 0.06 s

You define the duration of this blocking with the Cross-blocking time parameter. The default setting of 0.06 s (about 3 periods) has proven practicable. Set the time as short as possible and check the value during the closure tests. The parameter Cross-blocking time is inactive at Cross-blocking = no.

Parameter: Start flt.rec

- Default setting (_:114) Start flt.rec = yes

With the Start flt.rec parameter, you determine whether a fault record should be started upon pickup of the inrush-current detection. The following settings are possible:

Parameter Value	Description
no	No fault recording starts with pickup.
yes	The fault recording starts with pickup. When the protection function is blocked by the inrush-current detection, a fault recording is started nevertheless.

6.51.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inrush detect.				
_:1	Inrush detect.:Mode		• off • on • test	on

Addr.	Parameter	C	Setting Options	Default Setting
_:106	Inrush detect.:Operat.-range limit Imax	1 A @ 100 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	7.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	37.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	7.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	37.500 A
_:111	Inrush detect.:Blocking with CWA		• no • yes	yes
_:110	Inrush detect.:Blocking with 2. harmonic		• no • yes	yes
_:102	Inrush detect.:2nd harmonic content		10 % to 45 %	15 %
_:112	Inrush detect.:Cross-blocking		• no • yes	no
_:109	Inrush detect.:Cross-blocking time		0.03 s to 200.00 s	0.06 s
_:114	Inrush detect.:Start flt.rec.		• no • yes	yes

6.51.6 Information List

No.	Information	Data Class (Type)	Type
Inrush detect.			
_:81	Inrush detect.:>Block stage	SPS	I
_:54	Inrush detect.:Inactive	SPS	O
_:52	Inrush detect.:Behavior	ENS	O
_:53	Inrush detect.:Health	ENS	O
_:300	Inrush detect.:2.harmonic phase A	SPS	O
_:301	Inrush detect.:2.harmonic phase B	SPS	O
_:302	Inrush detect.:2.harmonic phase C	SPS	O
_:305	Inrush detect.:CWA	SPS	O
_:306	Inrush detect.:Cross-blocking	SPS	O
_:55	Inrush detect.:Pickup	ACD	O

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6.52 Power Protection (P,Q), 3-Phase

6.52.1 Overview of Functions

The 3-phase power protection (P, Q) function (ANSI 32) is used to:

- Detect whether the active or reactive power rises above or drops below a set threshold
- Monitor agreed power limits and output warning indications
- Detect both active and reactive power feedback in the power systems or on electric machines
- Detect machines (motors, generators) running without load and output an indication to shut them down.
- Be integrated into any automation solution, for example, to monitor very specific power limits (further logical processing in CFC)

6.52.2 Structure of the Function

The 3-phase power protection (P, Q) function can be integrated in function groups, which provide measured voltages and currents of the 3-phases for calculation of the power.

The 3-phase power protection (P,Q) function comes with one factory-set stage each for the active and the reactive power. The following stages are preconfigured:

- Power P>
- Power Q>
- Power P<
- Power Q<

A maximum of 4 active power stages and 4 reactive power stages can be operated simultaneously in the function. The tripping stages have an identical structure.

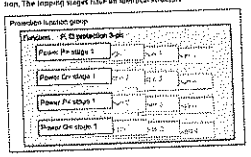

Figure 6-430 Structure/Embedding of the Function

Logical Combination of Output Signals

The operate indications of the active and reactive power stage(s) can be logically combined in CFC. When an operate indication is present in both the active and the reactive power stage, an alarm indication is generated.

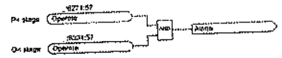

Figure 6-431 Logical Combination of Operate Indications in CFC

6.52.3 Active Power Stage

Logic of a Stage

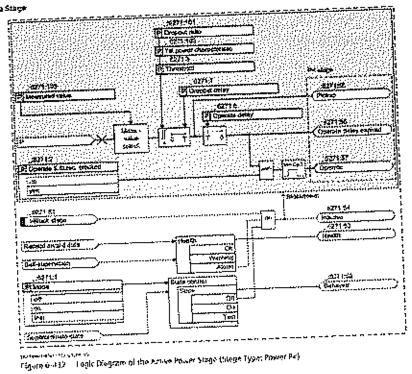

Figure 6-432 Logic Diagram of the Active Power Stage (Stage Type: Power P>)

Measured Value

The Measured value parameter is used to specify which measured power value is analyzed by the tripping stage. Possible settings are positive seq. power and the phase-selective power power of phase A, power of phase B or power of phase C.

Pickup Characteristic

With the stage type you specify if the stage works as a greater stage (stage type: Power P>) or as a smaller stage (stage type: Power P<).

The Threshold parameter is used to define the pickup threshold of the stage. The Tilt power characteristic parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.

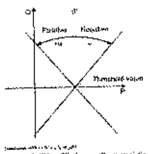

Figure 6-433 Tilt Power Characteristic

Pickup

The stage compares the selected power value with the set Threshold. Depending on the stage type (Power P> or Power P<) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter Operate delay) continues to run. Once the Operate delay has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal >Block stage.

6.52.4 Reactive Power Stage

Logic of a Stage

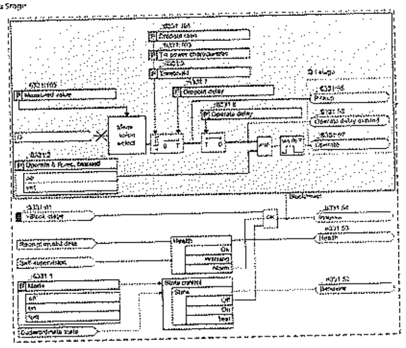

Figure 6-434 Logic Diagram of the Reactive Power Stage (Stage Type: Power Q<)

Measured Value

The Measured value parameter is used to specify which measured power value is processed by the respective stage. Possible settings are positive seq. power and the phase-selective powers power of phase A, power of phase B and power of phase C.

Pickup Characteristic

With the stage type you specify, if the stage work as a greater stage (stage type: Power Q>) or as a smaller stage (stage type: Power Q<).

The Threshold parameter is used to define the pickup threshold of the stage. The Tilt power characteristic parameter is used to define the tilt of the pickup characteristic. The figure below shows the definition of the signs.

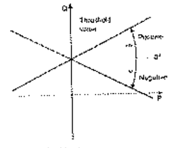

Figure 6-435 Tilt Power Characteristic

Pickup

The stage compares the selected power value with the set Threshold. Depending on the stage type (Power Q> or Power Q<) being above or falling below the threshold value will lead to a pickup.

Dropout Delay

A delay can be set for the dropout when the measured value falls below the dropout threshold. The pickup is maintained for the specified time. The time delay of the tripping (parameter Operate delay) continues to run. Once the Operate delay has elapsed, the stage trips.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking the stage is possible externally or internally via the binary input signal >Block stage.

6.52.5 Application Example

The setting of the function will be explained using an active/reactive power range as an example. If the apparent power phasor is within the power range (in Figure 6-436 tripping zone defined by character stics), an alarm indication is generated. For this purpose, you have to make an AND operation of the stage indications of the active and reactive power stage in CFC. The function used is 3 phase power measurement. Figure 6-436 shows the threshold values and the location of the characteristics in the PQ diagram.

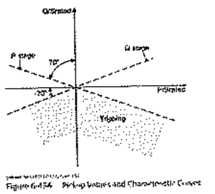

Figure 6-436 Pickup Values and Characteristic Curves

6.52.6 Setting Notes for the Active Power Stage

Stage Type

In the following example, a drop of the active power below a threshold is to be monitored. In the 3-phase circuit breaker (P, Q) function, work with the stage type Power P<.

Parameter: Measured value

- Recommended setting value (_:6271:105) Measured value = positive seq. power

The Measured value parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value (_:6271:3) Threshold = 0 %

The Threshold parameter is used to define the pickup threshold of the active power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter Threshold to 0%.

> **NOTE**
>
> If you use several settings groups, consider the following:
>
> - The dropout value of a stage must have the same sign in all settings groups.
> - Switching from a positive dropout value to a negative dropout value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
> - If you want to change the sign of the dropout value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group disable the stage there.

Parameter: Dropout ratio

- Recommended setting value (_:6271:101) Dropout ratio = 1.05

A hysteresis of 5 % is sufficient for most applications. The setting value for the lower stage is therefore 1.05.

Parameter: Tilt power characteristic

- Recommended setting value (_:6271:103) Tilt power characteristic = +70°

The Tilt power characteristic parameter is used to incline the pickup characteristic. In the above example, an inclination is required. The setting value is +70° (for a definition of the sign, see Figure 6-433).

Parameter: Dropout delay

- Recommended setting value (_:6271:7) Dropout delay = 70 ms

The Dropout delay parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 70 ms.

Parameter: Operate delay

- Recommended setting value (_:6271:6) Operate delay = 100 ms

The Operate delay must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.52.7 Setting Notes for the Reactive Power Stage

Stage Type

In the example, the reactive power is to be monitored if it falls below the threshold. In the 3-phase circuit breaker (P, Q) function, work with the stage type Power Q<.

Parameter: Measured value

- Recommended setting value (_:6331:105) Measured value = positive seq. power

The Measured value parameter is used to specify which measured power value is evaluated. For 3-phase measurement, Siemens recommends to evaluate the positive-sequence system power.

Parameter: Threshold

- Recommended setting value (_:6331:3) Threshold = 0 %

The Threshold parameter is used to define the pickup threshold of the reactive power stage. In the example, the pickup characteristic runs across the point of origin of the coordinates. Set the parameter Threshold to 0%.

> **NOTE**
>
> If you use several settings groups, consider the following:
>
> - The dropout value of a stage must have the same sign in all settings groups.
> - Switching from a positive dropout value to a negative dropout value or vice versa is not allowed. As a result, DIGSI reports an inconsistency.
> - If you want to change the sign of the dropout value of a stage in an additional settings group, instantiate a new stage and enable it. If the new stage should not be effective in another settings group, disable the stage there.

Parameter: Dropout ratio

- Recommended setting value (_:6331:101) Dropout ratio = 0.95

A hysteresis of 5 % is sufficient for most applications. The setting value for the lower stage is therefore 0.95.

Parameter: Tilt power characteristic

- Recommended setting value (_:6331:103) Tilt power characteristic = +20°

The Tilt power characteristic parameter is used to incline the pickup characteristic. In the example (see Figure 6-436), the power characteristic has a tilt of 20°. Set the Tilt power characteristic parameter to +20° (for a definition of the sign, see Figure 6-435).

Parameter: Dropout delay

- Recommended setting value (_:6331:7) Dropout delay = 20 ms

The Dropout delay parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value (_:6331:6) Operate delay = 100 ms

The Operate delay must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.52.8 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Power P> 1				
_:6241:1	Power P> 1:Mode		• off • on • test	off
_:6241:2	Power P> 1:Operate & flt.rec. blocked		• no • yes	no
_:6241:104	Power P> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6241:3	Power P> 1:Threshold		-200.0 % to 200.0 %	80.0 %
_:6241:101	Power P> 1:Dropout ratio		0.90 to 0.99	0.95
_:6241:103	Power P> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6241:7	Power P> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6241:6	Power P> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power PC 2				
_:6271:1	Power P< 1:Mode		• off • on • test	off
_:6271:2	Power P< 1:Operate & flt.rec. blocked		• no • yes	no
_:6271:105	Power P< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6271:3	Power P< 1:Threshold		-200.0 % to 200.0 %	5.0 %
_:6271:101	Power P< 1:Dropout ratio		1.01 to 1.10	1.05
_:6271:103	Power P< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °

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Addr.	Parameter	C	Setting Options	Default Setting
_:6271:104	Power P< 1:Pickup delay		• no • yes	yes
_:6271:7	Power P< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6271:6	Power P< 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q> 1				
_:6301:1	Power Q> 1:Mode		• off • on • test	off
_:6301:2	Power Q> 1:Operate & flt.rec. blocked		• no • yes	no
_:6301:105	Power Q> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6301:3	Power Q> 1:Threshold		-200.0 % to 200.0 %	20.0 %
_:6301:101	Power Q> 1:Dropout ratio		0.90 to 0.99	0.95
_:6301:103	Power Q> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6301:7	Power Q> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6301:6	Power Q> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q< 1				
_:6331:1	Power Q< 1:Mode		• off • on • test	off
_:6331:2	Power Q< 1:Operate & flt.rec. blocked		• no • yes	no
_:6331:105	Power Q< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6331:3	Power Q< 1:Threshold		-200.0 % to 200.0 %	-30.0 %
_:6331:101	Power Q< 1:Dropout ratio		0.90 to 0.99	0.95
_:6331:103	Power Q< 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6331:104	Power Q< 1:Pickup delay		• no • yes	yes
_:6331:7	Power Q< 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6331:6	Power Q< 1:Operate delay		0.00 s to 60.00 s	1.00 s

6.52.9 Information List

No.	Information	Data Class (Type)	Type
Power P> 1			
_:6241:81	Power P> 1:>Block stage	SPS	I
_:6241:54	Power P> 1:Inactive	SPS	O
_:6241:52	Power P> 1:Behavior	ENS	O
_:6241:53	Power P> 1:Health	ENS	O
_:6241:55	Power P> 1:Pickup	ACD	O
_:6241:56	Power P> 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:6241:57	Power P> 1:Operate	ACT	O
Power P< 1			
_:6271:81	Power P< 1:>Block stage	SPS	I
_:6271:54	Power P< 1:Inactive	SPS	O
_:6271:52	Power P< 1:Behavior	ENS	O
_:6271:53	Power P< 1:Health	ENS	O
_:6271:55	Power P< 1:Pickup	ACD	O
_:6271:56	Power P< 1:Operate delay expired	ACT	O
_:6271:57	Power P< 1:Operate	ACT	O
Power Q> 1			
_:6301:81	Power Q> 1:>Block stage	SPS	I
_:6301:54	Power Q> 1:Inactive	SPS	O
_:6301:52	Power Q> 1:Behavior	ENS	O
_:6301:53	Power Q> 1:Health	ENS	O
_:6301:55	Power Q> 1:Pickup	ACD	O
_:6301:56	Power Q> 1:Operate delay expired	ACT	O
_:6301:57	Power Q> 1:Operate	ACT	O
Power Q< 1			
_:6331:81	Power Q< 1:>Block stage	SPS	I
_:6331:54	Power Q< 1:Inactive	SPS	O
_:6331:52	Power Q< 1:Behavior	ENS	O
_:6331:53	Power Q< 1:Health	ENS	O
_:6331:55	Power Q< 1:Pickup	ACD	O
_:6331:56	Power Q< 1:Operate delay expired	ACT	O
_:6331:57	Power Q< 1:Operate	ACT	O

6.53 Reverse Power Protection

6.53.1 Overview of Functions

The Reverse-power protection function (ANSI 32R):

- Monitors the motor operation of generators and thus detects driving power failure
- Prevents endangering the turbine (e.g. the turbine-blade damage due to overheating) by opening the circuit breaker of the system
- Protects a turbo-generator set

For the generator, there is a danger that the turbo-generator set accelerates and reaches overspeed in case of an incorrect residual-steam passage (quick-stop valves defective) after the circuit breaker has opened. Consequently, disconnecting the system (opening the circuit breaker of the system) shall only occur after reverse power (active-power consumption) has been detected.

6.53.2 Structure of the Function

The Reverse-power protection function comes factory set with 1 stage. A maximum of 2 stages can be operated simultaneously within the function.

In all function groups, the function works with a 3-phase voltage and current interface. Depending on the current transformer used, this is the Voltage/current 3-phase function group or the Generator stator function group.

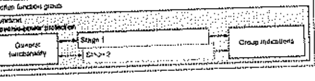

Figure 6-437 Structure/Embedding of the Function

6.53.3 General Functionality

6.53.3.1 Description

Logic of the Function

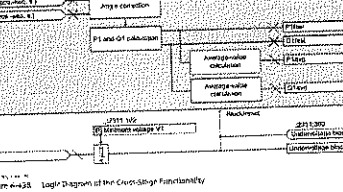

Figure 6-438 Logic Diagram of the Cross-Stage Functionality

Calculating the Reverse Power

The reverse power protection calculates the active power from the symmetrical components of the fundamental components of the voltages and currents. It generates the average value of the active power over a fixed number of cycles. Since positive-sequence variables are used for evaluation, the reverse power is determined independently of unbalance in currents or voltages. The frequency tracking sampled values are used for calculation. The determined reverse power corresponds to the load on the driving-power side. The calculated active-power value corresponds to the total active power.

Taking the phase-displacement angle of the voltage and current transformers into account, the function calculates the exact active power even with a high apparent power and a small cos φ. A constant correction angle $φ_{corr}$ makes correction possible. The influence of the current transformer angle error is predominant here. Determine this constant correction angle when you commission the protection device in the plant and adjust it as specified in the table (see table [illegible]).

Power Calculation and Angle Correction

To satisfy the high measuring accuracy requirements, the power measured value is additionally averaged over 16 cycles before it is supplied to the protection function. The active power is calculated from the symmetrical components vectors of voltage V1 and current I1. The total power is evaluated as power. The complex apparent power results from the following relationship. The real component is the active power:

$S = 3V_1 \cdot I_1^* = 3V_1 e^{jφ_V} \cdot I_1 e^{-jφ_I} = 3V_1 I_1 e^{j(φ_V - φ_I)}$

$P = 3V_1 I_1 \cos(φ_V - φ_I)$

The angle error between voltage transformer and current transformer has a strong influence on the measuring accuracy. With the parameter (_:2311:101) Angle correction, you can correct the angle error. The following 2 methods are possible here:

- Determine the angle error from the transformer test report data. Ask the transformer manufacturer for these values when you order the transformer.
- While the generator is connected to the power system, measure to determine the angle error (see chapter 10.15.2 Primary Test).

The influence on the power-system voltage makes it very difficult to test high-power generators with a measurement while the generator is connected to the power system. In this case, you must determine the angle error from the transformer test report data (see chapter 6.53.3.2 Application and Setting Notes). Alternatively, you can use instrument transformers with small angle errors. This is ensured with class 0.2 instrument transformers (voltage and current). The following equation describes the influence of the angle error:

$P = 3V_1 I_1 \cos(φ_V + φ_{VT} - (φ_I + φ_{CT})) = 3V_1 I_1 \cos(φ_V - φ_I - (φ_{CT} - φ_{VT}))$

The angle error to be corrected results as:

$φ_{corr} = φ_{CT} - φ_{VT}$

To rotate in the correct direction, the correction angle is considered with inverted sign inside the unit.

Functional Measured Values

You can use the following functional measured values to check the behavior of the protection function and to support commissioning. The total power is represented as the measured value.

Measured Value	Description	
P1fast	Positive-sequence system active power calculated per cycle	Angle correction influences the measured value
Q1fast	Positive-sequence system reactive power calculated per cycle	Angle correction influences the measured value
P1avg	Positive-sequence system active power calculated from P1fast over 16 cycles	Input value for Reverse power protection
Q1avg	Positive-sequence system reactive power calculated from Q1fast over 16 cycles	–

6.53.3.2 Application and Setting Notes

In the general functionality, you can adjust the parameter (_:2311:101) Angle correction. The parameter results from the angle error of the primary transformer. In SIPROTEC 5, the input transformers are calibrated so that the angle error is negligible. You can assume an error of < 0.1°. There is no difference between a protection input and an instrument transformer input.

> **NOTE**
>
> If you use class 0.2 instrument transformers on the primary side to avoid the influence of the angle, you can connect a protection device with a protection current transformer without any problems.
>
> Class 0.2 voltage transformers have a maximum admissible angle error of 10 min (0.17°). The angle error of a class 0.2 measuring current transformer at rated current is approximately 10 min, at 0.2 I_{rated} = 15 min, and at 0.05 I_{rated} = 30 min.

Parameter: Angle correction

- Default setting (_:2311:101) Angle correction = 0°

To determine the correction angle via measurement with the primary system, follow the instructions in chapter 10.15.2 Primary Test.

You can use the method that is explained in the following section to derive the necessary correction angle from the transformer measuring reports.

Example

This example uses a class 0.2 voltage transformer with a rated burden of 45 VA. The following data was taken from the measuring report:

Table 6-20 For Phase A

V/V_N	$S_b = S_N$		$S_b = S_N/4$	
	$ε_U$ [%]	$δ_U$ [min]	$ε_U$ [%]	$δ_U$ [min]
0.8	-0.16	0.31	0.16	-0.34
1	-0.15	0.43	0.15	-0.24
1.2	-0.16	0.68	0.14	-0.06

The values resulting for the phases B and C are almost identical.

Furthermore, a termination with a rated burden (other measuring devices are still connected) is assumed so that an angle error of +0.43 min (rated-voltage value) is used as the calculation variable.

A current transformer of type 5P… is used here. This current transformer features a gap that limits the remanence to 10 %. However, this gap results in larger angle errors. The following tables show excerpts from the test reports.

Table 6-21 Phase A

I/I_N [%]	$S_b = S_N$ (cos β = 0.8)	
	$ε_I$ [%]	$δ_I$ [min]
100	0.331	46.40

Table 6-22 Phase B

I/I_N [%]	$S_b = S_N$ (cos β = 0.8)	
	$ε_I$ [%]	$δ_I$ [min]
100	0.247	35.10

Table 6-23 Phase C

I/I_N [%]	$S_b = S_N$ (cos β = 0.8)	
	$ε_I$ [%]	$δ_I$ [min]
100	0.302	41.10

Since the positive-sequence system power is evaluated in the device, take the sign into account when you add the angle errors per phase, and divide the result by 3.

The following value results in this example:

$$δ_I[\text{min}] = \frac{1}{3}(δ_{I,A} + δ_{I,B} + δ_{I,C}) = \frac{1}{3}(46.40 + 35.10 + 41.10) = 40.87 \text{ min}$$

The resulting correction angle is:

$$φ_{corr}[\text{min}] = φ_{VT} - φ_{CT} = 0.43 \text{ min} - 40.87 \text{ min} = -40.44 \text{ min}$$

$$φ_{corr}[°] = \frac{φ_{corr}[\text{min}]}{60} \cdot 1° = \frac{-40.44}{60} \cdot 1° = -0.674°$$

Set the parameter (_:2311:101) Angle correction = -0.67°.

Parameter: Minimum voltage V1

- Default setting (_:2311:102) Minimum voltage V1 = 5.000 V

With the parameter Minimum voltage V1, you can limit the operating range of the reverse-power protection. If the positive-sequence voltage falls below the set value, the reverse-power protection is deactivated. If no other restrictions are known, the recommendation is using the default setting.

6.53.3.3 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Angle correction		-10.00 ° to 10.00 °	0.00 °
_:2311:102	General:Minimum voltage V1		0.300 V to 60.000 V	5.000 V

6.53.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:Undervoltage blocking	SPS	O
_:2311:301	General:P,long	MV	O
_:2311:302	General:Q,long	MV	O
_:2311:303	General:P,last	MV	O
_:2311:304	General:Q,last	MV	O

6.53.4 Stage Description

6.53.4.1 Description

Logic of the Stage

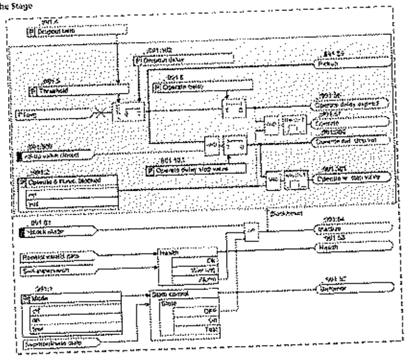

Figure 6-439 Logic Diagram of the Reverse-Power Protection Stage

Trip Command

To bridge brief power consumption during synchronization or during power swings caused by system incidents, tripping (shutdown of the generator via reverse power) is delayed by a settable time (for example, 10 s).

A brief delay is enough when the quick-stop valve is closed. Couple the position of the quick-stop valve via the binary input signal >Stop valve closed. When quick stop is tripped, the short Operate delay thus becomes effective.

Blocking the Stage

In the event of blocking, the picked up stage will be reset. Blocking of the stage is possible externally or internally via the binary input signal >Block stage.

6.53.4.2 Application and Setting Notes

If reverse power occurs in a power plant, the turbo-generator set must be disconnected from the electrical power system. Operating the turbine without the minimum steam flow (cooling effect) is dangerous. For a gas turbine cogeneration unit, the motor load can also be too great for the electrical power system.

Parameter: Threshold

- Recommended setting value (_:991:3) Threshold = -1.00 %

The friction losses that have to be overcome mainly determine the active power consumed by a turbo-generator set. Depending on the plant, the consumed active power is of the following range:

Steam turbines	$P_{reverse}/S_{rated}$ = 1.00 % to 3.00 %
Diesel drives	$P_{reverse}/S_{rated}$ > 5.00 %
Gas turbines	$P_{reverse}/S_{rated}$ = up to 10.00 %

You can measure the reverse power of the turbo-generator set yourself in a primary test by using the protection function. Set the setting value $P_{reverse}$ for example, to 0.5 times the value of the measured reverse power. This power is shown additionally in the functional measured values in the Reverse-power protection function (P,avg). For large machines with very small reverse power, you must use the angle-error correction option of the current and voltage transformers.

> **NOTE**
>
> In the current-input selection, you can select protection current transformers or instrument transformers on the device side. Since the transformers are calibrated at the factory, there are hardly any differences between the transformers for the Reverse-power protection function. You can thus always select device inputs with a protection current transformer.
>
> In contrast, a primary current transformer significantly influences the measuring accuracy via its angle error. The angle error of a class 0.2 instrument transformer is significantly smaller than the angle error of a class 5P protection current transformer. A separate function group is necessary for the connection to an instrument transformer. Use a Voltage/current 3-phase function group and load the Reverse-power protection function from the library.
>
> Do not connect the Reverse-power protection function to a linear core-type transformer (for example, a TPZ type), as these transformers have a large angle error (for example, approx. 180 min).

Parameter: Dropout delay

- Recommended setting value (_:991:102) Dropout delay = 0.00 s

With the Dropout delay parameter, the pickup can be latched. It is necessary to latch the pickup, for example, if leaking steam valves prevent a constant consumed active power, and pickup starts chattering.

Parameter: Dropout ratio

- Recommended setting value (_:991:4) Dropout ratio = 0.60

The default value is valid for small reverse-power values. It can be increased if the active-power consumption is greater. For an active-power setting at -5 %, for example, a Dropout ratio of about 0.85 is admissible.

Parameter: Operate delay

- Recommended setting value (_:991:6) Operate delay = 10.00 s

With reverse power without quick-stop valve, there can be a brief reverse-power consumption after synchronization and during power swings after a system incident (after a 3-phase short circuit, for example). With the parameter Operate delay, you can bridge the short reverse-power consumption with an operate delay of approximately 10 s.

Parameter: Operate Delay with Quick-Stop Tripping

- Recommended setting value (_:991:103) Operate delay stop valve = 1.00 s

If a fault leads to quick-stop tripping, the reverse-power protection switches off after quick-stop tripping with a short delay. This is accomplished with an oil pressure switch or a limit switch at the quick-stop valve. For the tripping, make sure that the reverse power only results from the missing driving power on the turbine side. A tripping delay is necessary to bridge the active-power transient associated with a sudden valve closing operation until a steady-state active-power value is achieved. To do this, set the parameter Operate delay stop valve to approximately 1.00 s to 3.00 s. For a gas turbine cogeneration unit, set the value to approximately 0.50 s.

The set times are additional time delays. These additional time delays do not include the operating times (measurement, relay) of the protection function.

6.53.4.3 Parameter

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:991:1	Stage 1:Mode		• off • on • test	off
_:991:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:991:3	Stage 1:Threshold		-30.00 % to -0.30 %	-1.00 %
_:991:4	Stage 1:Dropout ratio		0.40 to 0.99	0.60
_:991:102	Stage 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:991:6	Stage 1:Operate delay		0.00 s to 60.00 s	10.00 s
_:991:103	Stage 1:Operate delay stop valve		0.00 s to 60.00 s	1.00 s

6.53.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:991:81	Stage 1:>Block stage	SPS	I
_:991:500	Stage 1:>Stop valve closed	SPS	I
_:991:54	Stage 1:Inactive	SPS	O
_:991:52	Stage 1:Behavior	ENS	O
_:991:53	Stage 1:Health	ENS	O
_:991:55	Stage 1:Pickup	ACD	O
_:991:56	Stage 1:Operate delay expired	ACT	O
_:991:57	Stage 1:Operate	ACT	O
_:991:300	Stage 1:Operate del. stop val.	ACT	O
_:991:301	Stage 1:Operate w. stop valve	ACT	O

6.54 Voltage Measuring-Point Selection

6.54.1 Overview of Functions

The function block Voltage measuring-point selection can:

- Provide the ability to switchover the voltage measuring points to be applied, if various voltage measuring points are connected to the voltage interface of the function group
- Select the correct voltage based on the switch position of the plant

If more than one voltage measuring points are connected to the same voltage interface of the function group, use the Voltage measuring-point selection function block in the function group to select the correct voltage based on the switch position of the plant.

The Voltage measuring-point selection is a common functionality for the function groups of the protected objects.

6.54.2 Function Description

The Voltage measuring-point selection function block realizes the selection of voltage measuring points by a logic block chart. The logic block chart controls the input VMP-ID selection depending on the switch positions of disconnectors.

Example

Figure 6-440 shows an example of voltage measuring-point selection for the function group Capacitor bank in a double busbar application.

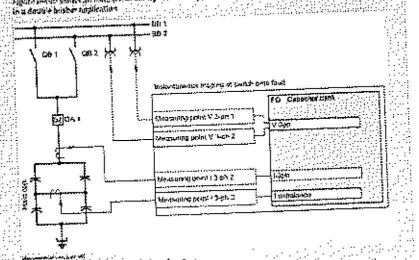

Figure 6-440 Double Busbar with Capacitor Bank

Connecting Measuring Points to Capacitor Bank Function Group

Figure 6-441 shows the connection of the function group Capacitor bank with several measuring points in DIGSI. The ID of each measuring point appears in the bracket after the name.

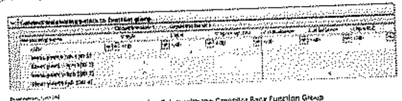

Figure 6-441 Connecting the Measuring Points with the Capacitor Bank Function Group

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

- The connection type must be identical for all measuring points connected to the same interface of the function group.
- The rated voltage (primary and secondary) must be identical for all measuring points connected to the same interface.
- If more than 1 measuring point is connected to one voltage interface, a function block must be added to enable the selection of the voltage measuring point.

6.54.3 Application and Setting Notes

CFC Control

The voltage measuring point is selected by logic block chart on basis of the measuring point IDs. If more than one measuring point is connected to the interface of the function group, instantiate the function block Voltage measuring-point selection from the library in the corresponding function group.

In order to ensure the correct measuring-point connection for the function group, a logic block chart has to define the actual valid IDs for the input VMP-ID selection of the function block.

The following logic block chart implementation is based on the example given in Figure 6-440.

If the Disconnector 1 (QB1) is closed and no matter what the position the Disconnector 2 (QB2) is, the value 2 is the output of CFC block mux_d_1 and transferred to the input VMP-ID selection. Then, the Meas.point V-3ph with ID 2 is selected as the reference voltage. Similarly, the Meas.point V-3ph with ID 3 is selected as the reference voltage if the Disconnector 1 (QB1) is not closed (open or in intermediate position) while Disconnector 2 (QB2) is closed.

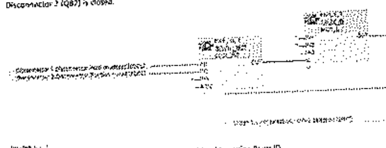

Figure 6-442 Logic Block Chart: Voltage Selection Using Measuring Point ID

However, the disconnectors might be both open or in a transient state. In this case, the input IN4 of the block bool_int_3 becomes true, the value 0 is used as the ID for voltage selection input VMP-ID selection. If ID 0 is selected, then all voltage values of the respective function group interface are set to 0 V immediately. An alarm indication Selection invalid is issued and the indication Health is issued as OK. In case you want to supply the function group with voltage values under the condition that both disconnectors are open or in transient state, fuse one on the other busbar, you can alter the CFC chart respectively.

NOTE

An invalid measured-value selection (ID = 0 or an ID of a non-connected measuring point) for input [illegible] selection results in the following:

- The voltage measured values are displayed as failure.
- The validity of the voltage measured values is set to invalid.
- The indication Health is set to Alarm.
- The indication Selection invalid becomes true.

6.54.4 Information List

No.	Information	Data Class (Type)	Type
V-MP selection			
_:21	V-MP selection:V-MP ID selection	INS	I
_:53	V-MP selection:Health	ENS	O
_:311	V-MP selection:Selection invalid	SPS	O

6.55 Current-Jump Detection

6.55.1 Overview of Functions

The Current-jump detection function has the following tasks:

- Detection of jumps in the phase or zero-sequence current (ΔI)
- Generation of an indication when the measurands change by more than a configured threshold value from one system period to the next

The function for detecting jumps in the phase or zero-sequence current is an additional function used for indication purposes or for further processing in user-specific CFC logic. Pick-up of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.55.2 Structure of the Function

The Current-jump detection function is used in protection function groups based on current measurement. It can be instantiated multiple times.

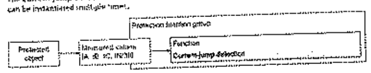

Figure 6-443 Structure/Embedding of the Function

6.55.3 Function Description

Current-jump detection operates directly with the sampled values without numeric filtering. This provides very short response times to sudden changes in the current. The method used is not sensitive to slow changes of amplitude or frequency.

Using a configurable selection of measured values, you can select from 3 line currents or the residual current. Current-jump detection is phase-selective for the line current A, B and C.

The difference from the previous sampled value of the last system cycle is calculated for each sampled value. The rectified average is then determined for a ½ system cycle from this differential signal Δi(t). The rectified average for sinusoidal measurands is then converted into RMS value ΔI by subsequent multiplication by 1.11. The resultant measurand ΔI is then compared with the threshold value.

If the parameter (_:101) Threshold is exceeded, the output indication Jump is generated. If you have selected the phase currents for measurement, the output indication data type used includes the separate phase information. If you have selected the residual current for measurement, the output indication data type used includes the 3I0 information. If the current-jump detection responds ($\Delta I_{[illegible]}$), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value ($\Delta I_{[illegible]}$) in accordance with the logic in Figure 6-444. Dynamic increase of the dropout threshold value achieves optimally short dropout times.

The output indication Pulse is formed with the configurable timer (_:102) Minimum pulse length. As a consequence this output indication has a consistent minimum size. If you activate the binary input >Pulse extension, you can prolong the pulse duration even further. If the binary input >Pulse extension has been activated, the indication Pulse drops off when the configured time has elapsed and the falling edge of the binary input is detected.

Logic

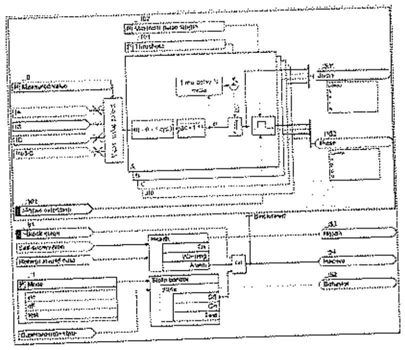

Figure 6-444 Current-Jump Detection Logic

6.55.4 Application and Setting Notes

Parameter: Measured value

- Default setting (_:9) Measured value = phase currents

With the parameter Measured value, you set whether the line current(s) or the residual current is to be used for jump detection.

Parameter Value	Description
phase currents	The tripping stage evaluates the line currents IL1, IL2 and IL3 phase-selectively to detect a jump.
zero-sequence current	The tripping stage evaluates the residual current IN(3I0) to detect a jump.

Parameter: Threshold

- Default setting (_:101) Threshold = 0.20 A for I_{rated} = 1 A or 0.50 A for I_{rated} = 5 A

With the parameter Threshold, you set the threshold value for the measurand which, when exceeded, generates the output indication Jump.

Parameter: Minimum pulse length

- Default setting (_:102) Minimum pulse length = 0.10 s

With the parameter Minimum pulse length, you specify a consistent minimum size for the output indication Pulse.

6.55.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I-jump det. #				
_:1	I-jump det. #:Mode		• off • on • test	off
_:9	I-jump det. #:Measured value		• phase currents • zero-sequence current	phase currents
_:101	I-jump det. #: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
_:101	I-jump det. #: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
_:102	I-jump det. #:Minimum pulse length		0.05 s to 60.00 s	0.10 s

6.55.6 Information List

No.	Information	Data Class (Type)	Type
I-jump det. #			
_:81	I-jump det. #:>Block stage	SPS	I
_:501	I-jump det. #:>Pulse extension	SPS	I
_:54	I-jump det. #:Inactive	SPS	O
_:52	I-jump det. #:Behavior	ENS	O
_:53	I-jump det. #:Health	ENS	O
_:301	I-jump det. #:Jump	ACT	O
_:302	I-jump det. #:Pulse	ACT	O

6.56 Voltage-Jump Detection

6.56.1 Overview of Functions

The Voltage-jump detection function has the following tasks:

- Recognition of jumps in the phase or zero-sequence voltage (ΔV)
- Generation of an indication when the measurands change by more than a configured threshold value from one system cycle to the next.

The function for detecting jumps in the phase or zero-sequence voltage is an additional function used for indication purposes or for further processing in user-specific CFC logic. Pick-up of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.56.2 Structure of the Function

The Voltage-jump detection function is used in protection function groups based on voltage measurement. It can be instantiated multiple times.

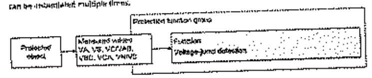

Figure 6-445 Structure/Embedding of the Function

6.56.3 Function Description

Voltage-jump detection operates directly with the sampled values without numeric filtering. This provides very short response times to sudden changes in the voltage. The method used is not sensitive to slow changes of amplitude or frequency.

By using a configurable selection of measured values, you can select from phase-to-ground voltages, phase-to-phase voltages or the zero-sequence voltage. Voltage-jump detection is phase-selective.

The difference from the previous sampled value of 1 system cycle is calculated for each sampled value. The rectified average is then determined for a ½ system cycle from this differential signal Δv(t). The rectified average for sinusoidal measurands is then converted to a RMS value ΔV by subsequent multiplication by 1.11. The resultant measurand ΔV is then compared with the threshold value.

If the parameter (_:101) Threshold is exceeded, the output indication Jump is generated. If the measured value is set to phase-to-phase, the sudden change in voltage is signaled selectively for the individual measuring elements that have picked up (Jump VAB, Jump VBC or Jump VCA). If you have selected the phase-to-phase or phase-to-ground voltages for measurement, the output indication data type used includes the separate phase information. If you have selected the zero-sequence voltage for measurement, the output indication data type used includes the 3I0 information. If the voltage-jump detection responds ($\Delta V_{[illegible]}$), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value $\Delta U_{[illegible]}$ in accordance with the information in Figure 6-446. Dynamic increase of the dropout threshold value achieves optimally short dropout times.

A timing element is added to the indication Jump. The element generates a pulse from this. The length of this pulse can be set using the parameter (_:102) Minimum pulse length. This gives the output indication Pulse a reliable minimum size. If you activate the binary input >Pulse extension, you can prolong the pulse duration even further. If the binary input >Pulse extension has been activated, the indication Pulse drops off when the configured time has elapsed and the falling edge of the binary input is detected. If

the measured value is set to phase-to-phase, the pulse duration is signaled selectively for the individual measuring elements that have picked up (Pulse VAB, Pulse VBC or Pulse VCA).

Logic

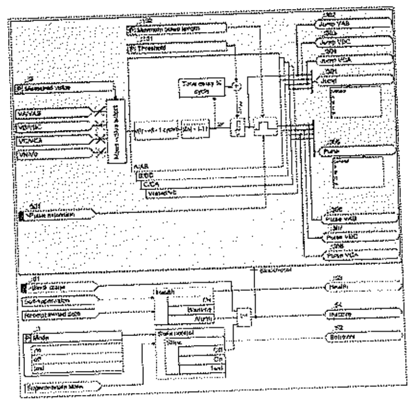

Figure 6-446 Voltage-Jump Detection Logic

6.56.4 Application and Setting Notes

Parameter: Measured value

- Default setting (_:9) Measured value = phase-to-ground

With the parameter Measured value, you specify which measured values of voltage are to be used for determining the voltage jumps.

Parameter Value	Description
phase-to-ground	The tripping stage evaluates the phase-to-ground voltages VA, VB and VC.

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Parameter Value	Description
phase-to-phase	The tripping stage evaluates the phase-to-phase voltages VAB, VBC and VCA.
zero-sequence voltage	The tripping stage evaluates the zero-sequence voltage VN/V0.

Parameter: Threshold

- Default setting (_:101) Threshold = 5.000 V

With the parameter Threshold, you set the threshold value for the measurand which, when exceeded, generates the output indication Jump.

Parameter: Minimum pulse length

- Default setting (_:102) Minimum pulse length = 0.10 s

With the parameter Minimum pulse length, you specify a consistent minimum size for the output indication Pulse.

6.56.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-jump det. #				
_:1	V-jump det. #:Mode		• off • on • test	off
_:9	V-jump det. #:Measured value		• phase-to-ground • phase-to-phase • zero-sequence voltage	phase-to-ground
_:101	V-jump det. #:Threshold		0.300 V to 340.000 V	5.000 V
_:101	V-jump det. #:Threshold		0.300 V to 340.000 V	5.000 V
_:102	V-jump det. #:Minimum pulse length		0.01 s to 60.00 s	0.10 s

6.56.6 Information List

No.	Information	Data Class (Type)	Type
V-jump det. #			
_:81	V-jump det. #:>Block stage	SPS	I
_:501	V-jump det. #:>Pulse extension	SPS	I
_:54	V-jump det. #:Inactive	SPS	O
_:52	V-jump det. #:Behavior	ENS	O
_:53	V-jump det. #:Health	ENS	O
_:301	V-jump det. #:Jump	ACT	O
_:302	V-jump det. #:Jump VAB	SPS	O
_:303	V-jump det. #:Jump VBC	SPS	O
_:304	V-jump det. #:Jump VCA	SPS	O
_:305	V-jump det. #:Pulse	ACT	O
_:306	V-jump det. #:Pulse VAB	SPS	O
_:307	V-jump det. #:Pulse VBC	SPS	O

No.	Information	Data Class (Type)	Type
_:308	V-jump det. #:Pulse VCA	SPS	O

7 Control Functions

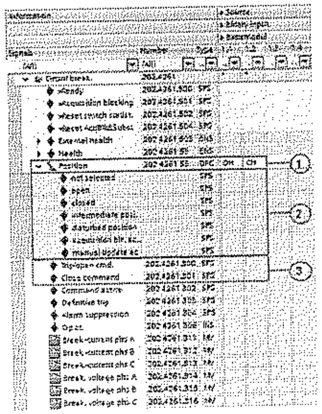
7.1 Introduction

7.1.1 Overview

The SIPROTEC 5 series of devices offers powerful command processing capability as well as additional functions that are needed when serving as bay controllers for the substation automation technology or when providing combi-protection. The object model for the devices is based on the IEC 61850 standard, making the SIPROTEC 5 series of devices ideally suited for use in systems employing the IEC 61850 communication protocol. In view of the function blocks necessary for the control functions, other logs are also used.

7.1.2 Concept of Controllables

The concept of so-called controllables is based on the data model described in IEC 61850. Controllables are objects that can be controlled, such as a switch with feedback. The model of a transformer tap changer, for example, contains controllables. The controllables are identifiable by their last letter C of the data type (for example, DPC – Double Point Controllable/Double Command with feedback or BSC – Binary-Controlled Step Position Indication / transformer tap command with feedback).



(1) Position (connect with binary inputs)
(2) Signalization of the current condition
(3) Command output (connect with relay)

The trip, opening and the close commands are connected to the relays. For the trip command, a choice between saved and unsaved output is possible. The position is connected with 2 binary inputs (double point indication). In addition, signals are available that display the current state of the switch (not selected, off, on, intermediate position, disturbed position). These signals can be queried in CFC for example in order to build interlocking conditions.

Control Models

You can set the operating mode of the controllables by selecting the control model.

4 different control models are available:

- Direct without feedback monitoring (direct w. normal secur.)
- With reservation (SBO)[1] without feedback monitoring (SBO w. normal secur.)
- Direct with feedback monitoring (direct w. enh. security)
- With SBO with feedback monitoring (SBO w. enh. security)

The next figure shows the command sources, command types, and control models.

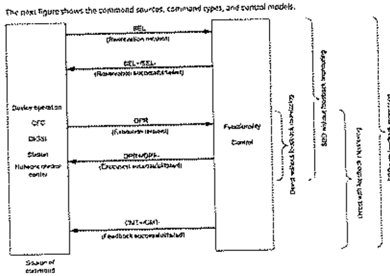


Figure 7-1 Command Sources, Command Types and Control Models

The figure shows the control models (right) with the respective control mechanisms (center). The standard control model for a switching command in an IEC 61850 compliant system is SBO with feedback monitoring (SBO w. enh. security). This control model is the default setting for newly created switching devices.

[1] SBO: Select Before Operate

7.2 Switching Devices

7.2.1 General Overview

The following switching devices can be found in the DIGSI 5 library in the Circuit-breaker and Switching-devices function groups (see the following images).

- FG Circuit breaker
  - Circuit breaker
  - Circuit breaker (status only)
  - Circuit breaker (control)

Figure 7-2 Selecting the Circuit-Breaker Switching Device Using the DIGSI Circuit-Breaker Function Group Menu

- Switching devices
  - Tap changer
  - Disconnector
  - Disconnector (status only)

Figure 7-3 Selecting the Remaining Switching Devices Using the DIGSI Switching-Devices Menu

7.2.2 Switching Device Circuit Breaker

7.2.2.1 Structure of the Circuit Breaker Switching Device

This chapter describes the control properties of the Circuit breaker switching device.

The Circuit breaker switching device contains the following function blocks that are needed for control:

- Function block Circuit breaker
- Function block Control
- Function block Interlocking

This corresponds to the logical nodes XCBR, CSWI, and CILO in IEC 61850.

In the case of protection devices or combined protection and control devices, additional functions can be contained in the circuit breaker switching device, for example, synchrocheck, the automatic reclosing (AREC), the trip logic or manual On function. However, these are not relevant for the control function. The description of these functions is in the chapter Protection and Automatic Functions.

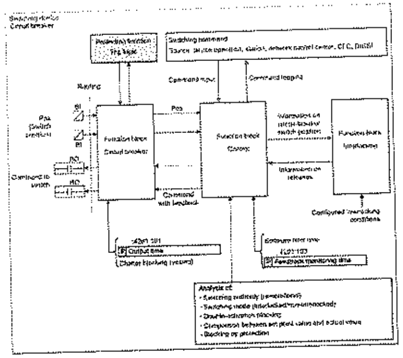


Figure 7-4 Control Function Blocks of the Circuit-Breaker Switching Device

The circuit breaker in DIGSI 5 is linked with the binary inputs that acquire the switch position via information routing. The circuit breaker in DIGSI 5 is also linked with the binary outputs that issue the switching commands.

The Circuit breaker switching device is available in 4 different types:

- **3-pole circuit breaker (control only)**
  This switching device contains the Control, Interlocking, and Circuit-breaker function blocks needed for control. The standard situation for the control function is that the SIPROTEC 5 device switches all 3 poles of the circuit breaker On or Off together. The Synchronization function can also be added.
- **3-pole circuit breaker**
  This switching device contains additional base function blocks for protection functions (for example, trip logic, Manual close, circuit-breaker test).
- **1-pole circuit breaker**
  This switching device is intended for 1-pole tripping via the protection functions and contains the same base function blocks for protection as the 3-pole circuit breaker switching device.
- **Circuit breaker (status only)**
  This switching device contains only the Circuit-breaker function block. It is used to acquire the position of a switch, for example, from a neighboring bay. This object type can be used to model switches that can only be read but not controlled by the SIPROTEC 5 device.

NOTE

When setting the parameters of a device, you will find 2 circuit-breaker types in the DIGSI 5 library:
- 3-pole circuit breaker or 1-pole circuit breaker, depending on the device type selected (3-pole or 1-pole tripping)
- Circuit breaker (status only)

Function Blocks of the Circuit Breaker

Table 7-1 Function Blocks of the Circuit-Breaker Function Group

Function Block	Description	Parameters	Function
Circuit breaker	The Circuit breaker function block in the SIPROTEC 5 device represents the physical switch.	Output time	The circuit breaker forms the switch position from the positions of the binary inputs and also outputs the command via the binary outputs.
Control	Command processing	Control model SBO time-out Feedback monitoring time Check switching authority Check if pos. is reached Check double activat. blk. Check blk. by protection	Command check, communication with the command source and with the function block Circuit breaker
Interlocking	Switchgear interlocking protection	Interlocking condition (deposited in CFC)	The interlocking functionality generates the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter 7.2.2.2 Application and Setting Notes.

Additional Setting Options of the Circuit Breaker Switching Element

The setting options of the circuit breaker are assigned to the function blocks on the basis of their relevance. Additional setting options of the circuit breakers that cannot be directly assigned to one of the 3 function blocks are nevertheless available:

Table 7-2 Setting Options of the Controllable Command with Feedback in the Control Function Block of the Circuit Breaker

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Position of the Control[1] function block
Retrigger filter (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the Control[1] function block
Message time before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp	Position of the Control[1] function block
Suppress intermediate position (yes/no)	When activated, only the intermediate position is suppressed by the duration of the software filtering time.	Position of the Control[1] function block

Properties	Function	To Be Found in
Treatment of spontaneous position changes (Gen. software filt./Spont. software filt.)	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. By selecting Spontaneous software filter, a separate filtering is activated for spontaneous position changes.	Position of the Control[1] function block
Spontaneous software filtering time	Software filtering time for spontaneous position changes	Position of the Control[1] function block
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the Control[1] function block
Spontaneous indication timestamp before filtering (yes/no)	Consideration of the hardware filtering time for position-detection time stamp in case of a spontaneous change	Position of the Control[1] function block
Inhibit intermediate position for a spontaneous chng. (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the Control[1] function block

[1] First click Position and then click the Details button in the Properties window (below).

Table 7-3 Setting Options of the Controllable Position in the Circuit Breaker Function Block (Chatter Blocking)

Properties	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the Circuit breaker[1] function block

[1] First click Position and then click the Details button in the Properties window (below).

Table 7-4 Additional Settings in the Device Settings Having Effects on the Circuit Breaker

Properties	Function	To Be Found in
Number of permissible status changes	Chatter-blocking setting values: Once for the entire device	Device settings (to be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter idle time		
Chatter check time		

The inputs and outputs as well as the setting options of the Circuit breaker and Control function blocks are described in the next section (see 7.2.2.3 Connection Variants of the Circuit Breaker).

Interlocking

The Interlocking function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, see chapter 7.4.1 Command Checks and Switchgear Interlocking Protection.

7.2.2.2 Application and Setting Notes

Circuit Breaker

The Circuit breaker function block in the SIPROTEC 5 device represents the physical switch device. The task of the circuit breaker is to replicate the switch position from the status of the binary inputs.

The following figure shows the logical inputs and outputs of the Circuit-breaker function block.

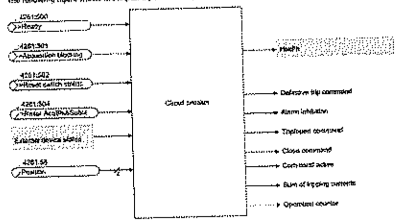


Figure 7-5 Logical Inputs and Outputs of the Circuit-Breaker Function Block

Table 7-5 and Table 7-6 list the inputs and outputs with a description of their function and type. For inputs, the effect of Quality = invalid on the value of the signal is described.

EXAMPLE

If the signal >Ready has the Quality = invalid, then the value is set to cleared. In problematic operating states, the circuit breaker should signal that it is not ready for an Off-On-Off cycle.

Table 7-5 Inputs of the Circuit-Breaker Function Block

Signal Name	Description	Type	Default Value If Signal Quality = Invalid
>Ready	The signal >Ready indicates that the OFF-ON-OFF cycle is possible with the circuit breaker. This signal is used for the AREC standby status.	SPS	Going
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset AcqBlk&Subst	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is activated, setting the acquisition blocking and the substitution is blocked.	SPS	Unchanged
>Reset switch statist.	Among other things, the binary input sets the operation counter for the switch to the value 0.	SPS	Unchanged

Signal Name	Description	Type	Default Value If Signal Quality = Invalid
External health	The binary input External health reflects the circuit-breaker status (EHealth). This input will be set by the CFC using the BUILD_ENS block. In turn, BUILD_ENS can query binary inputs that represent the conditions OK, Warning, Alarm (as a result of the function Trip-circuit supervision).	ENS	Unchanged
Position	The signal Position can be used to read the circuit breaker position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status Quality = invalid, then the standby status (EHealth) of the Circuit-breaker function block is set to Warning.

Table 7-6 Outputs of the Circuit-Breaker Function Block

Signal Name	Description	Type
Definitive trip	Protection has finally been tripped.	SPS
Alarm suppression	The signaling contact for external alarm suppression is suppressed during the runtime of automatic reclosing (optional) as well as during the command output of switching commands.	SPS
Op.ct.	The information counts the number of switching cycles of the circuit breaker.	INS
Trip/open cmd.	This logic output is responsible for the command output Off.	SPS
Close command	This logic output is responsible for the command output On.	SPS
Command active	The binary output Command active is responsible for signaling a running command (relay active or selected switching device (SBO)).	SPS
CB open hours	The statistic value counts the hours the circuit breaker is open.	INS
Operating hours	The statistic value counts the hours where at least one phase current is greater than the Current thresh. CB open parameter.	INS

Control

It is the task of the controls to execute command checks and establish communication between the command source and the circuit breaker. Using the control settings, you specify how the commands are to be processed.

Through the function SBO (Select Before Operate, reservation[3]) reserves the switching device prior to the actual switching operation, thus it remains locked for additional commands. Feedback monitoring provides information about the progress of the command while the command is in process, that means, informing whether or not the command was implemented successfully. These two options can be selected individually in the selection of the control model, so that 4 combinations in total are available (see the following table).

The control makes the following settings available (see next table).

Parameters	Default Setting	Possible Parameter Values
_:4201:101 Control model	SBO w. enh. security[4]	direct w. normal secur. SBO w. normal secur. direct w. enh. security SBO w. enh. security
_:4201:102 SBO time-out	30.00 s	0.01 s to 1800 s (Increment: 0.01 s)
_:4201:103 Feedback monitoring time	1.00 s	0.01 s to 1800 s (Increment: 0.01 s)

[3] In the IEC 61850 standard, reservation is described as Select Before Operate (SBO).
[4] The default setting is the standard circuit breaker for a switching transmission in IEC 61850 standard systems.

Parameters	Default Setting	Possible Parameter Values
_:4201:104) Check switching authority	yes	no yes advanced
_:4201:105) Check if pos. is reached	yes	no yes
_:4201:106) Check double activat. blk.	yes	no yes
_:4201:107) Check blk. by protection	yes	no yes

The following figure shows the logical inputs and outputs of the Control function block.

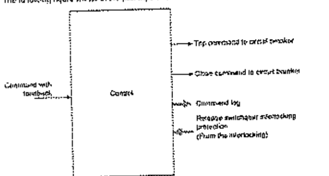


Figure 7-6 Logical Inputs and Outputs of the Control Function Block

Table 7-7 Control Function Block: Input and Output

Signal Name	Description	Type	Value if Signal Quality=invalid
Cmd. with feedback	With the Cmd. with feedback signal, the circuit breaker position is accepted via the double-point indication of the Circuit breaker function block, and the command is submitted.	Controllable (DPC) Unchanged	Unchanged

In the information routing of DIGSI 5, you may select a function key as a possible command source. In addition, it is displayed here if the command is activated by CFC. The logging is routed here.

7.2.2.3 Connection Variants of the Circuit Breaker

For each switching device, you can establish the number of poles (for example, 1-pole, 1.5-pole or 2-pole) that are switched with or without feedback. This results in the necessary amount of information to be processed, thus establishing the command type.

Whether the circuit breaker is triggered 1-, 1.5-, or 2-phase, depends on the design of the auxiliary and control-voltage system. In most cases, the activation of the opening coil of the circuit breaker is 1-pole.

Table 7-8 Meaning of the Abbreviations of the Connection Variants

Abbreviation	Meaning of the Abbreviations of the Connection Variants
BO	Binary output
L+, L-	Control voltage
A	Trip command
Unc	Close command

Table 7-9 Meaning of the Abbreviations in DIGSI

Abbreviation	Description of the Input in DIGSI
U	Unsaved trip command Click the right mouse button and enter U.
X	Close command Click the right mouse button and enter X for the respective binary output.
OH	The switching device feedback is in the position OFF, if there is voltage at the routed binary input (H). Click the right mouse button and enter OH.
OL	The switching device feedback is in the position OFF, if there is no voltage at the routed binary input (L). Click the right mouse button and enter OL.
CH	The switching device feedback is in the position ON, if there is voltage at the routed binary input (H). Click the right mouse button and enter CH.
CL	The switching device feedback is in the position ON, if there is no voltage at the routed binary input (L). Click the right mouse button and enter CL.
TL	Trip command stored Click the right mouse button and enter TL.

Connection Variant: 3-Pole Circuit Breaker

This is the standard type for the control function. All 3 individual poles of the circuit breaker are triggered together by a double command.

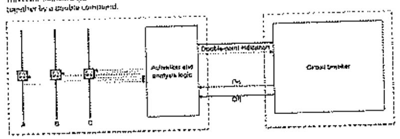


Figure 7-7 3-Pole Circuit Breaker

1-Pole Triggering

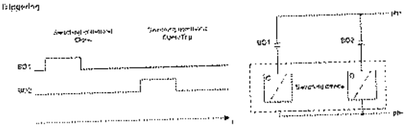


Figure 7-8 1-Pole Triggering

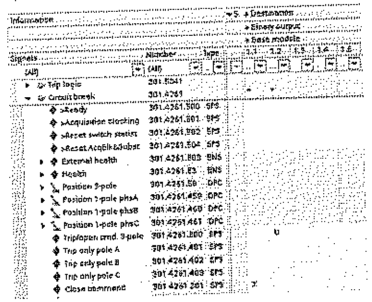


Figure 7-9 1-Pole Triggering, Routing in DIGSI

You can select the contacts for *On* and *Off* as desired. They need not necessarily be next to one another. The letter U represents an unlatched command. Alternatively, TL (latched tripping) may be selected.

1.5-Pole Triggering

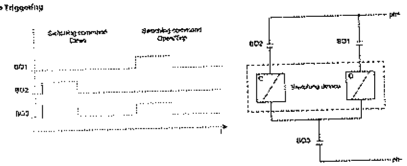


Figure 7-10 1.5-Pole Triggering

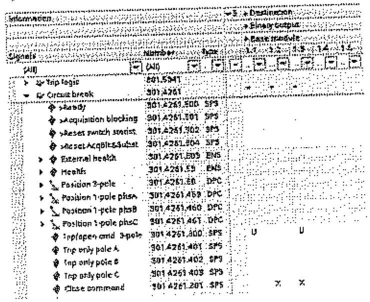


Figure 7-11 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering

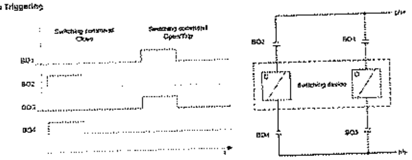


Figure 7-12 2-Pole Triggering

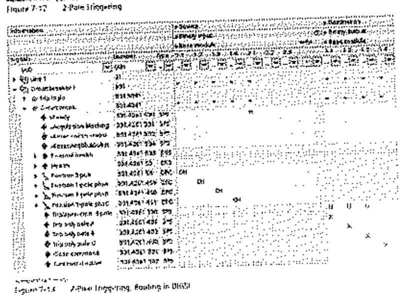


Figure 7-13 2-Pole Triggering, Routing in DIGSI

Connection Variant: 1-Pole Circuit Breaker

The 1-pole circuit breaker is used for separate activation and acquisition of the individual poles of a circuit breaker. It is intended for common use by 1-pole tripping protection and control functions.

> **NOTE**
>
> The use of the Circuit-breaker function group with binary inputs and binary outputs occurs once per device.

The control function in this type switches all 3 poles on or off simultaneously.

The protection functions can switch off 1-pole. The close command is always 3-pole. Optionally, only the open poles close.

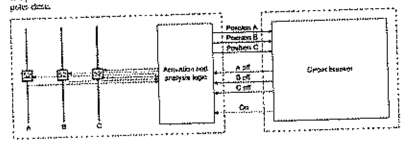


Figure 7-14 Circuit Breaker with 1-Pole Triggering

For the circuit breaker with 1-pole triggering, triggering takes place via one relay per phase for the trip command and via a 4th relay for the close command (see next figure).

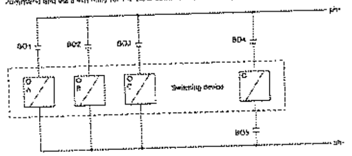


Figure 7-15 1-Pole Connection of a Circuit Breaker

796

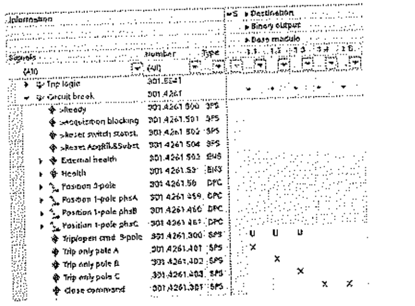
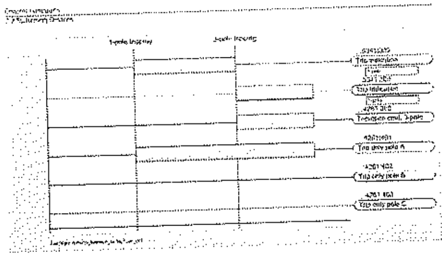


Figure 7-16 Routing in DIGSI

In the previous figure, the switch is connected 1-pole. The protection trip command is routed individually for the 3 phases (Trip only pole A to Trip only pole C). The protection trip command is routed for the 3 phases (Trip/open cmd. 3-pole). The control will always switch off the 3 poles of the switch. In addition, the 3 U (Unsaved) allocations of the indication and trip command are set to 3-pole. This routing is also used by protection functions that trip 3 poles. The close command is issued simultaneously for all 3 phases.

Example: Trip Command during Transition from 1-Pole to 3-Pole

During a transition from 1-pole to 3-pole tripping, Trip only pole A remains active. To inform, for example, an external AREC whether it is a 1-pole or 3-pole trip, you can use the indications Trip logic:Trip indication:1-pole and Trip logic:Trip indication:3-pole.



Acquisition of the Circuit-Breaker Position

The routing of the binary inputs for feedback of the switch position is done as shown in the previous figure (also see Chapter 5.2.7.3 Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information [illegible]).

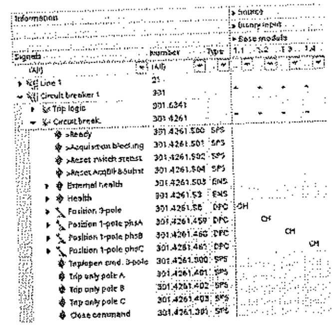


Figure 7-17 Routing of the 1-Pole in DIGSI

The meaning of abbreviations can be found in Table 7-6 and Table 7-7.

The indication Command active can also be routed to a binary output. This binary output is always active if either an On or trip command is pending, or the switching device was selected by the command control.

7.2.2.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated normal current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Breaker settings				
_:2311:112	General:Current thresh. CB open	1 A	0.030 A to 10.000 A	0.100 A
		5 A	0.150 A to 50.000 A	0.500 A
_:2311:113	General:1-pole operate allowed		• no • yes	yes
Trip logic				
_:5341:101	Trip logic:Trip at 2ph short circuit		• 3-pole • 1-pole, leading phase • 1-pole, lagging phase	3-pole
_:5341:102	Trip logic:3-pole coupling		• with pickup • with trip	with trip

Addr.	Parameter	C	Setting Options	Default Setting
_: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	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
CB test				
_:6151:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s

7.2.2.5 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
_:4261:503	Circuit break.:External health	ENS	I
_:4261:53	Circuit break.:Health	ENS	O
_:4261:58	Circuit break.:Position 3-pole	DPC	C
_:4261:459	Circuit break.:Position 1-pole phsA	DPC	C
_:4261:460	Circuit break.:Position 1-pole phsB	DPC	C
_:4261:461	Circuit break.:Position 1-pole phsC	DPC	C
_:4261:300	Circuit break.:Trip/open cmd. 3-pole	SPS	O
_:4261:401	Circuit break.:Trip only pole A	SPS	O
_:4261:402	Circuit break.:Trip only pole B	SPS	O
_:4261:403	Circuit break.:Trip only pole C	SPS	O
_:4261:301	Circuit break.:Close command	SPS	O
_:4261:302	Circuit break.:Command active	SPS	O
_:4261:303	Circuit break.:Definitive trip	SPS	O

No.	Information	Data Class (Type)	Type
_:4261:304	Circuit break.:Alarm suppression	SPS	O
_:4261:306	Circuit break.:Op.ct.	INS	O
_:4261:407	Circuit break.:Op.ct. A	INS	O
_:4261:408	Circuit break.:Op.ct. B	INS	O
_:4261:409	Circuit break.:Op.ct. C	INS	O
_:4261:322	Circuit break.:CB open hours	INS	O
_:4261:323	Circuit break.:Operating hours	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
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
Control			
_:4201:53	Control:Health	ENS	O
_:4201:58	Control:Cmd. with feedback	DPC	C
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
_:6151:312	CB test:Pole A open-close	SPC	C
_:6151:313	CB test:Pole B open-close	SPC	C
_:6151:314	CB test:Pole C open-close	SPC	C

7.2.3 Disconnector Switching Device

7.2.3.1 Structure of the Disconnector Switching Device

Like the circuit breaker, the Disconnector switching device contains the following 3 function blocks:

- Function block Disconnector
- Function block Control
- Function block Interlocking

This corresponds to the logical nodes XSWI, CSWI and CILO in IEC 61850.

NOTE

In contrast to the Circuit-breaker switching device, the Disconnector switching device cannot contain any additional functions because protection functions or synchronization can have no effect on the disconnector.

The following figure shows the structure of the Disconnector switching element:

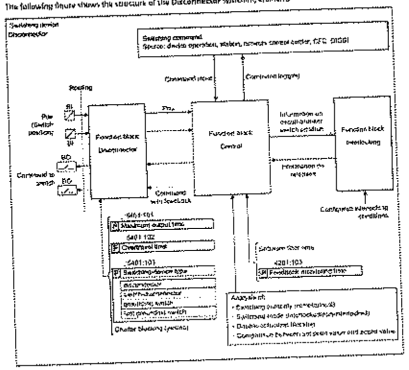


Figure 7-18 Control-Relevant Function Blocks of the Disconnector Switching Device

The Disconnector switching device behaves like the Circuit-breaker switching device. The only difference is the designation of the function block that the physical switch provides (disconnector instead of circuit breaker). Blocking by protection is not relevant in the analysis of the Control function block.

The Disconnector switching device is available in the DIGSI 5 library in 2 different variants:

- **Disconnector with 3-pole connection**
  The device switches all 3 poles of the disconnector on or off simultaneously.
- **Disconnector without triggering (only status detection, no control)**
  This variant is rarely encountered. It is encountered with grounding switches that frequently cannot be controlled, but only provide their current position. In addition, the position of a disconnector or a bypass switch can be acquired.

Function Blocks of the Disconnector

Table 7-10 Function Blocks of the Disconnector Function Group

Function Block	Description	Settings	Function
Disconnector	The disconnector represents the physical switch in the SIPROTEC 5 device.	Maximum output time Dwell time Switching-device type	The disconnector replicates the switch position from the status of the binary inputs and also transmits the command via the binary outputs.
Control	Command processing	Control model SBO time-out Feedback monitoring time Check switching authority Check if pos. is reached Check double activat. blk.	Command checks, communication with the command source and with the function block disconnector
Interlocking	Switchgear interlocking protection	Interlocking condition (depending on CFC)	The interlocking functionality generates the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter 7.2.3.2 Application and Setting Notes.

Additional Settings of Disconnector Switching Element

The settings of the disconnector are assigned to the function blocks on the basis of their relevance. Additional disconnector settings that cannot be directly assigned to one of the 3 function blocks and are identical to the circuit-breaker settings are available:

Table 7-11 Setting Options of the Controllable Command with Feedback in the Control Function Block of the Circuit Breaker

Properties	Function	To Be Found in
Software filtering time	Software filtering time for position detection	Position of the Control[1] function block
Retrigger filter (yes/no)	Switching retriggering of the filtering time on/off by changing the position	Position of the Control[1] function block
Message time before filtering (yes/no)	Consideration of the hardware filtering time for position detection time stamp	Position of the Control[1] function block

Properties	Function	To Be Found in
Suppress intermediate position (yes/no)	When activated, only the intermediate position is suppressed for the duration of the software filtering time.	Position of the Control[1] function block
Spontaneous position changes filtered by (Own software filter/Dat. software filt.)	If the General software filtering setting is selected, the general settings for software filtering of spontaneous position changes and for position changes caused by a switching command apply. By selecting Spontaneous software filter, a separate filter can be activated for spontaneous position changes.	Position of the Control[1] function block
Spontaneous software filter time	Software filtering time for spontaneous position changes	Position of the Control[1] function block
Spontaneous retrigger filter (yes/no)	Switching on/off retriggering of the filtering time by spontaneous position change	Position of the Control[1] function block
Spontaneous indication timestamp before filtering (yes/no)	Consideration of the hardware filtering time for position detection time stamp in case of a spontaneous change	Position of the Control[1] function block
Spontaneous suppress intermediate position (yes/no)	When activated, only the spontaneous change to the intermediate position is suppressed by the duration of the software filtering time.	Position of the Control[1] function block

(1) First click Position and then the Details key in the Properties window (below).

Table 7-12 Setting Options of the Controllable Position in the Disconnector Function Block (Chatter Blocking)

Properties	Function	To Be Found in
Chatter blocking (yes/no)	Switching chatter blocking on/off	Position of the Disconnector[1] function block

(1) First click Position and then the Details key in the Properties window (below).

Table 7-13 Additional Settings in the Device Settings with Effect on the Disconnector

Properties	Function	To Be Found in
Number of permissible state changes Chatter test time Number of chatter tests Chatter dead time Chatter test time	Chatter blocking setting value. Once for the entire device	Device settings (to be found under Settings)

The inputs and outputs as well as the setting options of the Disconnector switch function block are described in the next chapter (see 7.2.3.3 Trigger Variants of the Disconnector). The Control function block is described identically as the Circuit-breaker function block, with the exception that the command check blocking is available through protection only with the circuit breaker.

More information on this is can be found in chapter 7.2.3.2 Application and Setting Notes.

Interlocking

The Interlocking function block generates the releases for switchgear interlocking protection. The actual interlocking conditions are deposited in CFC. For more information on this, see section 7.4.2 Command Checks and Switchgear Interlocking Protection.

7.2.3.2 Application and Setting Notes

Disconnector

The disconnector represents the physical switch in the SIPROTEC 5 device. The task of the disconnector is to replicate the switch position from the status of the binary inputs.

The Disconnector function block is linked automatically via the information routing with the binary inputs that register the switch position and with the binary outputs that issue the switching commands.

The Disconnector function block makes the following settings available (see next table):

Settings	Default Setting	Possible Parameter Values
(_:5401:101) Maximum output time	10.00 s	0.01 s to 1800 s (increments: 0.01 s)
(_:5401:102) Dwell time	0.00 s	[illegible]
(_:5401:103) Switching-device type	disconnector	not-clr-disconnector disconnector grounding switch fast grounding switch

NOTE

The parameter Switching-device type is effective only on the IEC 61850 interface. This parameter is used to set the disconnector type for communication via an IEC 61850 interface. It is a mandatory data object in the IEC 61850 standard.

The following figure shows the logical inputs and outputs of the Disconnector function block.

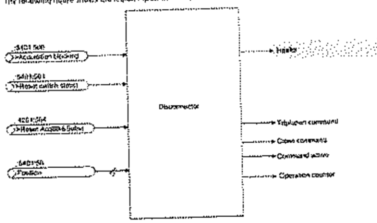


Figure 7-19 Logical Inputs and Outputs of the Disconnector Function Block

Table 7-14 and Table 7-15 list the inputs and outputs with a description of their function and type. For inputs, the effect on **Quality = invalid** on the value of the signal is described.

Table 7-14 Inputs of the Disconnector Function Block

Signal Name	Description	Type	Value if Signal Quality=invalid
>Acquisition blocking	The binary input activates acquisition blocking. You can also set this binary input with an external toggle switch.	SPS	Unchanged
>Reset AcqBlk&Subst	Acquisition blocking and the substitution of the circuit breaker are reset with this input. If the input is activated, setting of the acquisition blocking and of the substitution is blocked.	SPS	Unchanged
>Reset switch statist.	The binary input sets the operation counter for the switch to the value 0.	SPS	Unchanged
Position	The binary input Position can be used to read the disconnector position with double-point indication.	DPC	Unchanged

If the quality of the input signal assumes the status **Quality = invalid**, then the standby status (Health) of the Disconnector function block is set to Warning.

Table 7-15 Outputs of the Disconnector Function Block

Signal Name	Description	Type
Open command	This binary output is responsible for the command output Off.	SPS
Close command	This binary output is responsible for the command output On.	SPS
Command active	The binary output Command active is a running command for the signalization (command active or selected switching device). During Command active either an On or Off command is active.	SPS
Op.ct.	The information counts the number of disconnector switching cycles.	INS

Control

It is the task of the Control to execute command checks and establish communication between the command source and the disconnector. Using the control settings, you specify how the commands are to be processed.

Through the function SBO (Select Before Operate, reservation[1]) selects the switching device prior to the actual switching function, thus it remains locked for additional commands. Feedback monitoring provides information about the initiator of the command while the command is in process. That means: information whether or not the command was implemented successfully. These two options can be selected individually in the selection of the control model, so that 4 combinations in total are available (see the following table).

The Control makes the following settings available (see next table).

Settings	Default Setting	Possible Parameter Values
(_:4201:101) Control model	SBO w. enh. security[2]	direct w. normal secur. SBO w. normal secur. direct w. enh. security SBO w. enh. security
(_:4201:102) SBO time-out	30.00 s	

[1] In standard IEC 61850, reservation is described as Select before Operate (SBO).
[2] The Role 2 setting is the standard control model for a switching component according to the IEC 61850-compliant values.

Settings	Default Setting	Possible Parameter Values
(_:4201:103) Feedback monitoring time	10.00 s	-
(_:4201:104) Check switching authority	yes	no yes advanced
(_:4201:105) Check if pos. is reached	yes	no yes
(_:4201:106) Check double activat. blk.	yes	no yes

7.2.3.3 Trigger Variants of the Disconnector

The activation types are identical to those for the circuit breaker. The meaning of abbreviations can be found in 7.2.2.3 Connection Variants of the Circuit Breaker and 7.2.2.3 Connection Variants of the Circuit Breaker. Whether the disconnector is triggered for 1-, 1.5-, or 2-phases depends on the design of the auxiliary and control voltage system.

1-Pole Triggering

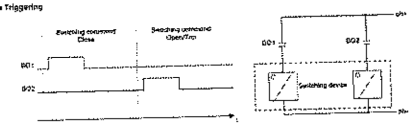


Figure 7-20 1-Pole Triggering

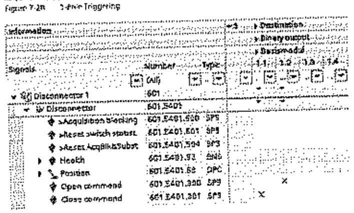


Figure 7-21 1-Pole Triggering, Routing in DIGSI

You can select the contacts for On and Off as desired. They need not necessarily be next to one another.

1.5-Pole Triggering

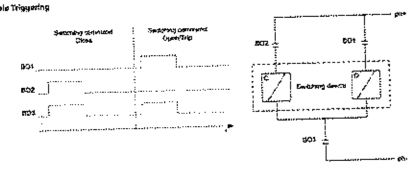


Figure 7-22 1.5-Pole Triggering

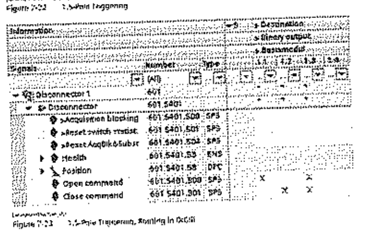


Figure 7-23 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering

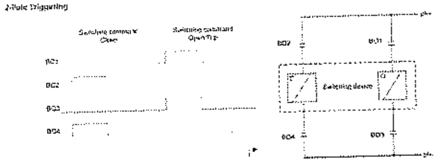


Figure 7-24 2-Pole Triggering

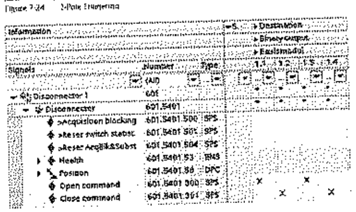


Figure 7-25 2-Pole Triggering, Routing in DIGSI

The feedback is routed via the position with the disconnector.

7.2.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
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	10.00 s
_:4201:104	Control:Check switching authority		• no • yes	yes

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

7.2.3.5 Information List

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

7.3 Switching Sequences

7.3.1 Overview of Functions

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

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

7.3.2 Function Description

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

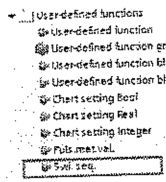


Figure 7-26 Function Block Switching Sequence in the Library

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

One Switching sequence function block is used per switching sequence. The function block is the interface for controlling and monitoring the condition of the CFC switching sequence. The task of the function block is to verify the relative conditions for control commands, for example, switching authority, interlocking conditions, etc. You can connect the signals of the function block with the CFC chart. They start and stop the switching sequence and provide data about the status of the switching sequence (see Figure 7-27). The CFC chart is used to activate the switching device that must be switched. The CFC blocks define, among other things, the switching devices that must be switched.

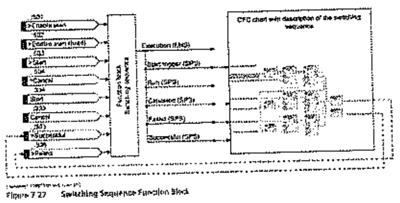


Figure 7-27 Switching Sequence Function Block

Starting and Canceling a Switching Sequence

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

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

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

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

On-Site Operation

If at least one Switching sequence function block is used in the device, a new Switching sequences entry is shown in the first line of the Control menu. If this menu item is selected, an overview of all switching sequences and the current status will be displayed (see Figure 7-28, example with 2 switching sequences). You can start or cancel the switching sequences from this menu.

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Figure 7-28
Overview of the Switching Sequences on the Device Display

7.3.3 Application and Setting Notes

This function block offers similar settings as the Control function block of a circuit breaker or disconnector (see chapter 7.2.1 General Overview).

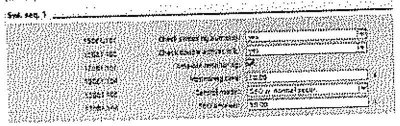

Figure 7-29 Settings of the Switching Sequence Function Block

Parameter: Check switching authority

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

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

Parameter: Check double activat. blk.

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

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

Parameter: Timeout monitoring

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

Parameter: Monitoring time

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

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

Parameter: Control model

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

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

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

Information

The Switching sequence function block provides the following data:

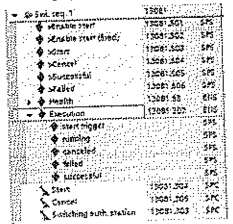

Figure 7-30 Data Provided by the Switching Sequence Function Block

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

- >Enable start: Connection to interlocking conditions (CFC) for the start of the entire switching sequence. Not in effect in the non-interlocked switching mode.
- >Enable start (fixed): Not revocable interlocking condition for the start of the entire switching sequence. In effect regardless of the switching mode.

If the time-out monitoring is enabled (parameter Timeout monitoring), the process feedback must take place via the inputs >Successful and >Failed. If the last switching command of the switching sequence was executed successfully, the input >Successful usually is set. To do this, connect the feedback of the last switching command from the CFC with this input of the function block during the device parameterization. If a switching command fails, this feedback can be captured by the input >Failed. The active switching sequence will be ended immediately and does not have to wait for a time out.

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

Example for a Switching Sequence with CFC

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

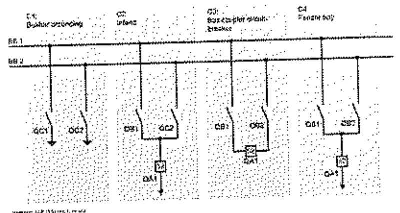

Figure 7-31 Example of a Substation

The switching sequence C4 Off (Figure 7-32) should switch off feeder bay C4. The circuit breaker is opened, followed by opening of one of the 2 busbar disconnectors.

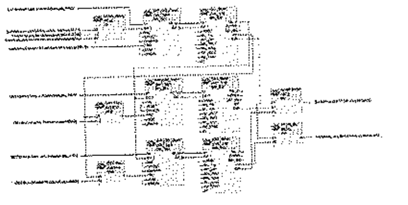

Figure 7-32 CFC Switching Sequence C4 Off

Command Execution

As described in section Starting and Canceling a Switching Sequence, Page 1196, the display page of the Control menu can be used to start the switching sequence. The Start - Trigger signal for indication Execution is used to recognize the start and initiates the switching sequence by pickup of TRIG in the DPC EXE building block of circuit breaker QA1. Building blocks DPC DEF and DPC EXE are always used in pairs. The DEF building block contains the type and nature of the command.

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

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

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

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

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

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

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

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

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

7.3.4 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting
_:102	Swi. seq. #:Check double activat. blk.		• no • yes	yes
_:103	Swi. seq. #:Time-out monitoring		• 0 • 1	true
_:104	Swi. seq. #:Monitoring time		0.02 s to 3600.00 s	10.00 s
_:105	Swi. seq. #:Control mode		• direct w. normal secur. • SBO w. normal secur.	SBO w. normal secur.
_:106	Swi. seq. #:SBO time-out		0.01 s to 1800.00 s	30.00 s
Switching authority				
_:151	Swi. seq. #:Swi.dev. related sw.auth.		• 0 • 1	false
_:152	Swi. seq. #:Specific sw. authorities		• 0 • 1	true
_:155	Swi. seq. #:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:153	Swi. seq. #:Num. of specific sw.auth.		2 to 5	2
_:154	Swi. seq. #:Multiple specific sw.auth.		• 0 • 1	false

7.3.5 Information List

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

7.4 Control Functionality

7.4.1 Command Checks and Switchgear Interlocking Protection

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

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

Confirmation IDs

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

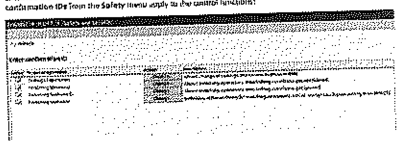

Figure 7-33 Confirmation IDs in DIGSI 5: Settings Menu

The following table identifies the meanings of the confirmation IDs:

Table 7-16 Relevant Confirmation IDs for Controls

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

Confirmation ID	Meaning	Description
Switching Authority	Release for switching authority Local	The confirmation ID is queried only for devices without a key switch; otherwise it is replaced with the key switch position.

The confirmation IDs are preset with the following values.

- Setpoints 222222
- Control (process, interlocked) 333333
- Control (not-interlocked) 444444
- Switching authority local 666666

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

To increase security, change these codes with DIGSI.

Switching Mode (Interlocked/Non-Interlocked)

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

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

⚠ **DANGER**

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

Erroneous switching operations can lead to severe or fatal injuries.

✧ Ensure manually that all checks have been implemented.

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

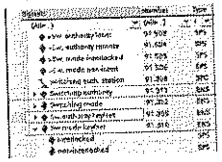

Figure 7-34 Switching Mode in Function Block General

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

Table 7-17 Relationship Between Switching Mode and Command Checks

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

Switching Authority

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

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

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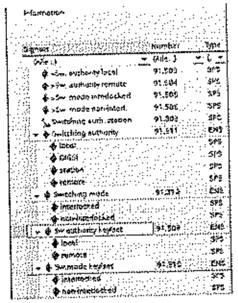

Figure 7-35 Display of Switching Authority and Switching Mode in Information Routing (in Function Block General)

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

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

Table 7-18 Dependency of the Switching Mode on the Key Switch Position and Switching Authority

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

The signals shown in Figure 7-35 in DIGSI 5 information routing have the following relationships:

- In terms of switching authority and switching mode, the respective key switch position serves as the input signal and the input signals in the matrix.
- The state of the switching authority and switching mode is indicated by corresponding output signals.
- The Switching authority and Switching mode functions link the input signals and in this way establish the output signals (see Figure 7-36 and Figure 7-37).

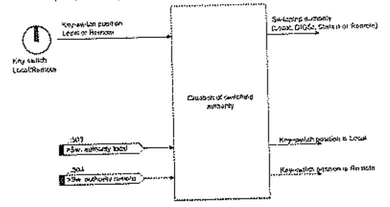

Figure 7-36 Establishing Switching Authority

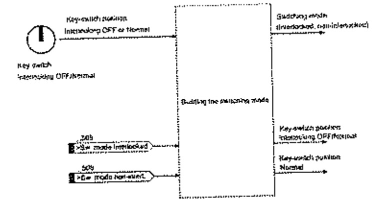

Figure 7-37 Establishing Switching Mode

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

The following additional settings are available for the switching authority:

- Activation of Switching Authority Station (defined in IEC 61850 Edition 2):
  If you would like to use this switching authority, set the check mark General/Control.
- Multiple Switching Authority Levels:
  This option permits switching commands from several command sources in the device if the switching authority Remote is selected. Subsequently, a distinction between these command sources can also be made. You can find more details in the following table. Activate this option by setting the check mark General/Control.
- Specific sw. authorities:
  You can enable additional options for the switching authority check. You can find more information about these options in chapter Specific Switching Authority, Page 1210. By default, these are not used.

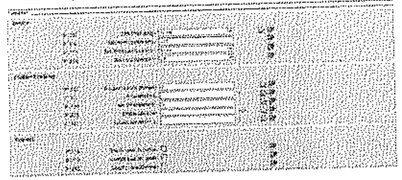

Figure 7-38 How to Activate the Station Switching Authority and to Enable Several Switching-Authority Levels

Table 7-19 Effect on Switching Authority when Several Switching-Authority Levels Are Enabled with/without Activation of the Station Switching Authority

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

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

Table 7-20 Result of a Switching Authority Check

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

Specific Switching Authority

Special switching authorities can be configured as extension of the switching-authority check. This makes it possible to differentiate the Remote command sources at the bay level. Switching authorities can be routed to or revoked from different control centers that can, for example, belong to different companies. Thus, precisely one of these command sources can switch at a certain time. This function is based on extending the switching-authority check by verifying the identifier of the command source (field Originator/orIdent of switching command). In order to turn on the function, go to General/Control and set the check mark for the parameter Specific sw. authorities. More settings for the configuration of the identifiers and the behavior of the function as well as additional signals appear (see Figure 7-39). In order to permit an additional command source to switch, you must activate that specific switching authority. In order to do this, set the controllable Enable sw. auth. 1 to Enable sw. auth. 5.

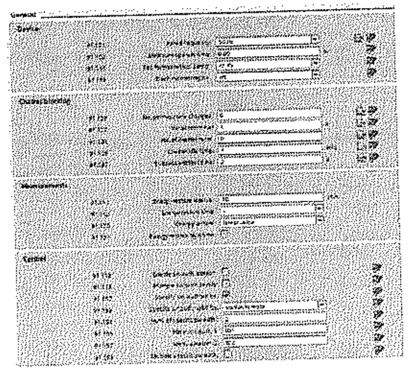

Figure 7-39 Activating Additional Options of the Switching Authority

The additional parameters allow you to set the following options:

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

Table 7-21 Result Derived from the Combination of the Parameter Value Specific sw.auth. valid for and the Level of the Command Source (Field originator/orCat of the Switching Command)

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

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

Table 7-22 Determining Switching Authority if Multiple Command Sources Are Available

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

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

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Switching auth. station	91.300	SPC	
Enable sw. auth. 1	91.304	SPC	
off		SPS	
on		SPS	
Enable sw. auth. 2	91.305	SPC	
off		SPS	
on		SPS	
Switching authority	91.311	ENS	
local		SPS	
DIGSI		SPS	
station		SPS	
remote		SPS	
Switching mode	91.312	ENS	
interlocked		SPS	
non-interlocked		SPS	
Sw authority keyset	91.309	ENS	
local		SPS	
remote		SPS	
Sw mode keyset	91.310	ENS	
interlocked		SPS	
non-interlocked		SPS	

Figure 7-40 Display of Switching Authority and Switching Mode in the Information Routing (in Function Block General), Example of 2 Activated Remote Switching Authorities

Individual Switching Authority and Switching Mode for the Switching Devices

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

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

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

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

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

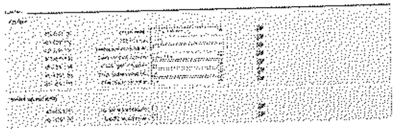

Figure 7-41 Additional Parameters for Switching Authorities in the Parameters of a Switching Device

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

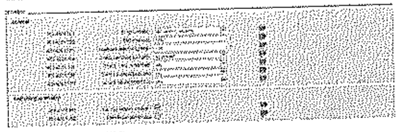

Figure 7-42 Expanded Parameters for the Switching Authority in the Switching Device

Control	401.4201		
>Sw. authority local	401.4201.501	SPS	
>Sw. authority remote	401.4201.502	SPS	
>Sw. mode interlocked	401.4201.503	SPS	
>Sw. mode non-interl.	401.4201.504	SPS	
Health	401.4201.53	ENS	
ok		SPS	
warning		SPS	
alarm		SPS	
Cmd. with feedback	401.4201.58	DPC	
Switching auth. station	401.4201.302	SPC	
Switching authority	401.4201.313	ENS	
local		SPS	
DIGSI		SPS	
station		SPS	
remote		SPS	
Switching mode	401.4201.314	ENS	
interlocked		SPS	
non-interlocked		SPS	

Figure 7-43 Individually Modifiable Switching Authority and Switching Mode for Switching Devices

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

authority and the switching mode. The inputs Switching authority and Switching mode indicate the state only for this switching device.

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

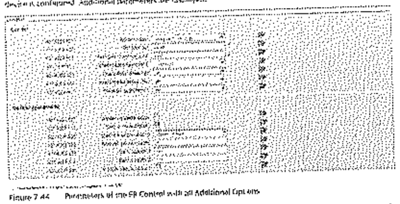

Figure 7-44 Parameters of the FB Control with all Additional Options

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

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

Figure 7-45 Specific Switching Authority, Modifiable for each Switching Device

Switching Direction (Set = Actual)

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

Switchgear Interlocking Protection

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

SIPROTEC 5 devices recognize 2 different types of interlocking conditions:

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

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

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

Signals	Number	Type
(All)	(All)	
Circuit breaker 1	201	
Trip logic	201.5341	
Circuit break..	201.4261	
Manual close	201.5341	
Control	201.4201	
Interlocking	201.4281	
>Enable opening	201.4281.500	SPS
>Enable closing	201.4281.501	SPS
>Enable opening (fixed)	201.4281.502	SPS
>Enable closing (fixed)	201.4281.503	SPS
Health	201.4281.53	ENS

Figure 7-46 Interlocking Signals at Function Block Interlocking

EXAMPLE

For interlocking

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

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

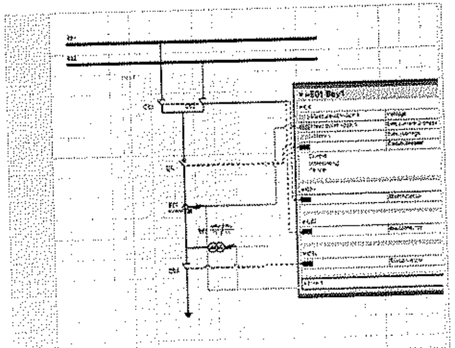

Figure 7-47 Feeder Bay for a Double Busbar System

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

Figure 7-48 Interlocking Chart for Bay Interlocking

Since the Disconnector function block provides the defined end-position On or Off, the available OR gate XOR is not necessary for interlocking. A simple OR suffices.

As can be seen in the CFC chart, the result of this check is connected to the >Enable on signal in the Interlocking function block in the Circuit breaker QA function group (see Figure 7-46).

EXAMPLE

For system interlocking

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

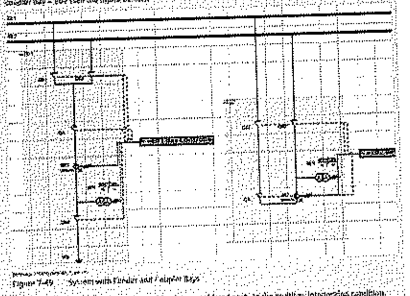

Figure 7-49 System with Feeder and Coupler Bays

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

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

QA_Off = NOT (=E01 Bus coupler closed)

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

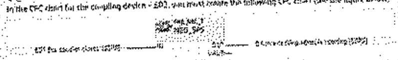

Figure 7-50 Interlocking Chart for Substation Interlocking

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

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

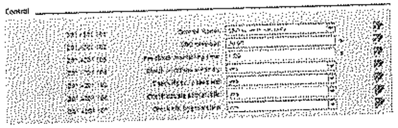

Figure 7-51 Activating the Double-Activation Blocking

With SIPROTEC 5, it is also possible to achieve multibay double-activation blocking. In this case, send the signal not selected to other devices for analysis using IEC 61850-GOOSE. This signal is available under Position in every Circuit breaker or Disconnector function block in the switching device function groups (see figure below).

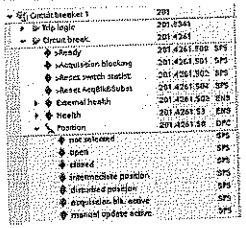

Figure 7-52 Signal Not selected in the Circuit-Breaker Function Block

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

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

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

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

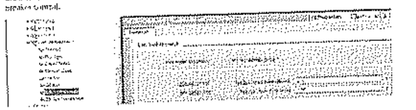

Figure 7-53 Command Execution

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

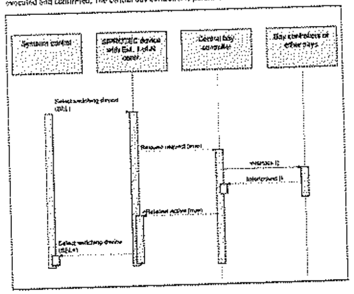

Figure 7-54 Setting the Blocking

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

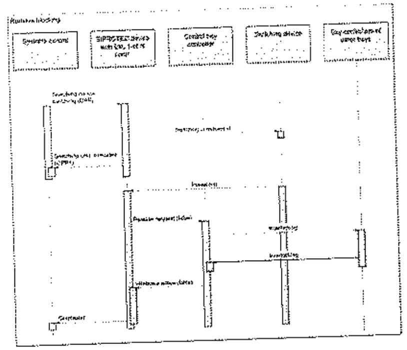

Figure 7-55 Terminating the Blocking

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

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

Blocking by Protection Function

- Default setting (_:107) Check blk. by protection = yes

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

The default setting for blocking by the protection function is therefore yes. If necessary, you can disable this blocking. You can find the settings on the same page as the double-activation blocking (see Figure 7-41).

NOTE

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

NOTE

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

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

- Group indication: Pickup (Function group Transformer)
- Circuit-breaker failure protection: Pickup (Circuit-breaker failure protection)

7.4.2 Command Logging

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

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

EXAMPLE

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

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

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

Figure 7-56 Positive Case (Display 1)

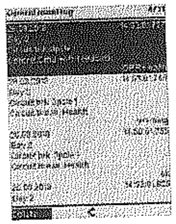

Figure 7-57 Positive Case (Display 2)

Figure 7-58 Positive Case (Display 1)

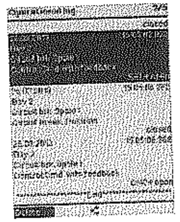

Figure 7-59 Positive Case with Command Cancellation

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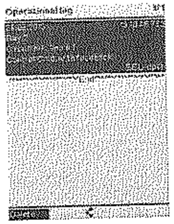


Figure 7-60 Negative Case (Blocked by Switchgear Interlocking)

Figure 7-61 Negative Case (Expiration of Feedback Supervision Time) (Display 1)

Figure 7-62 Negative Case (Expiration of Feedback Supervision Time) (Display 2)

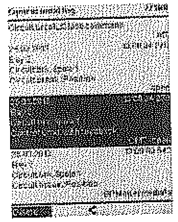


Figure 7-63 Negative Case (Expiration of Feedback Supervision Time) (Display 3)

Figure 7-64 Spontaneous Status Change

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

The following table shows the relationship.

Table 7-23 Relationship between the Reason for Transmission and the Value Logged

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

7.4.3 Settings

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

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

7.4.4 Information List

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

7.5 Synchronization Function

7.5.1 Overview of Functions

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

The following operating modes are covered:

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

7.5.2 Structure of the Function

The Synchronization function is used in the Circuit-breaker function group.

2 different types of stage can be used within the function:

- Synchrocheck stage
- Synchronous/asynchronous stage

Each of the stage types is preconfigured at the factory. You can operate maximum 2 stages of the synchrocheck stage type and maximum 6 stages of the synchronous/asynchronous type in parallel. In addition, the Expanded delta-f options stage type is available in the function library. It is not preconfigured.

As soon as the device is functional, the function measuring points are calculated and displayed.

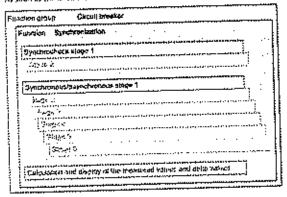


Figure 7-65 Structure/Embedding of the Function

7.5.3 Connection and Definition

Connection

You can find examples for the synchronization of line and busbar in the following 2 figures. Figure 7-65 shows an example for the synchronization of 2 busbars via bus coupler.

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

The selection of the voltages used for the synchronization depends on the device connection to the primary system:

- Connection of the primary system via 4 voltage inputs and hence use of a 1-phase and a 3-phase measuring point (Figure 7-66 and Figure 7-67):
  The voltage connected to the 1-phase measuring point is definitive here. If, for example, this is the phase-to-ground voltage V_A, the voltage V_A is also used by the other side of the 3-phase measuring point.
- Connection of the primary system via 6 voltage inputs and hence use of two 3-phase measuring points (Figure 7-68):
  The phase-to-phase voltage V_{AB} of both sides is always used for the test.

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

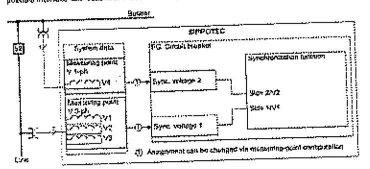


Figure 7-66 Synchronization of Line and Busbar, Connection via 4 Voltage Inputs

[1] Do not confuse the designations V1 and V2 with the numbering of the voltage inputs V1 to V4 (Figure 7-66) and V1 to V8 (Figure 7-67)

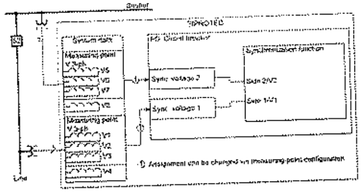


Figure 7-67 Synchronization of Line and Busbar, Connection via 6 Voltage Inputs

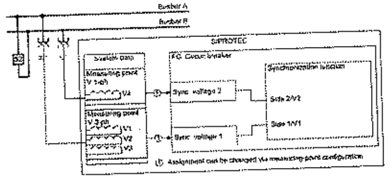


Figure 7-68 Synchronization of 2 Busbars via Cross Coupling, Connection via 4 Voltage Inputs

Definition of the Variables

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

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

Differential voltage dV = V2 − V1

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

Differential frequency df = f2 − f1

A positive result means that according to the example from Figure 7-68 the busbar frequency is greater than the line frequency.

Phase-angle difference dα = α2 − α1

The representation is limited to ±180°. A positive result means that α2 leads by a maximum of 180°. In the case of a negative value, α2 lags by a maximum of 180°. Figure 7-69 shows the circumstances. The phase angle α1 was added to the zero axis as a reference system.

If asynchronous systems are present and the frequency f2 is greater than f1, the angle dα then changes from the negative value to 0 and then to the positive value. As shown in Figure 7-69, the direction of rotation is counterclockwise (mathematically positive). At f2 < f1, the direction of rotation is clockwise.

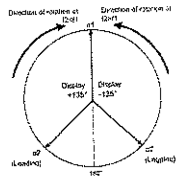


Figure 7-69 Phase Angle Difference Representation dα

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

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

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

7.5.4 General Functionality

Overview of a Synchronization Stage (Sync Stage)

A synchronization stage can be integrated in the following blocks (see Figure 7-70):

- Stage control with mode, state control, standby and blocking (description in this chapter)
- Supervision (description in this chapter)
- Functional sequence for issuing the closing release (see chapter 7.5.6 Sequence of Functions)

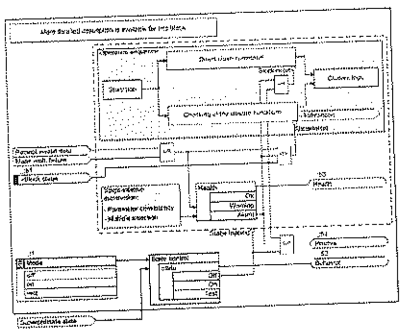


Figure 7-70 Overview of the Stage Logic

Stage Control

The normal stage control is used for a synchronization stage (see Figure 7-70).

Note the following special features:

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

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

Operating Range

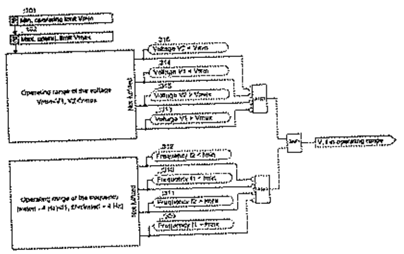


Figure 7-71 Logic of the Operating Ranges

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

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

Supervision

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

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

Measuring-Voltage Failure

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

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

Function Measured Values

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

Table 7-24 Protection-Specific Values of the Synchronization

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

Multiple Synchronization Points

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

Different Synchronization Conditions per Synchronization Point

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

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

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

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

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

Synchronization via a Transformer

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

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

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

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

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

Different Connection Types on Both Sides

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

EXAMPLE:
The 1-phase measuring point connected with Sync-voltage 1 records the phase-to-phase voltage V_{AB}. The 1-phase measuring point connected with Sync-voltage 2 records V_A. In this case the phase angle between V_{AB} and V_A taken into consideration the delta variable Δα during calculation.

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

7.5.5 Dynamic Measuring-Point Switching

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

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

Example

Figure 7-72 shows an example of a Synchrocheck in a breaker-and-a-half arrangement. If circuit breaker QA2 is to be closed, the reference voltages must be selected from several possible measuring points. The selection of measuring points is dependent on the switch positions of all circuit breakers and disconnectors.

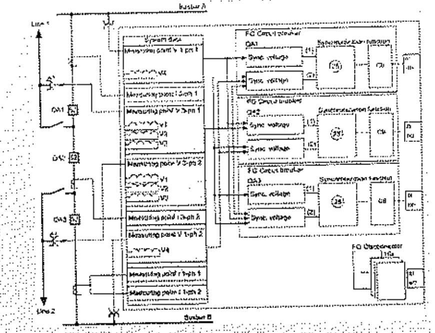


Figure 7-72 Synchronization in a Breaker-and-a-Half Arrangement

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

For circuit breakers QA1 and QA3, the busbar voltage (V_{sync1}) is available for one side, and 2 voltages (V_{sync2}) are available for the other side.

Connecting Measuring Points to Circuit-Breaker Function Group

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

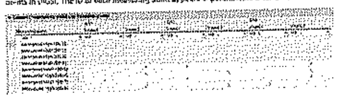


Figure 7-73 Connecting the Measuring Points with the Circuit Breaker Function Group

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

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

CFC Control

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

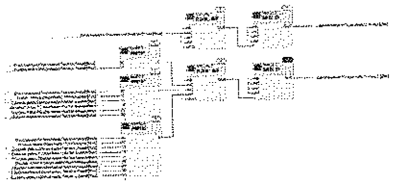


Figure 7-74 CFC Logic: Voltage Selection Using Measuring Point ID

If no measuring point can be selected because of the switch or disconnector positions, the ID 0 is used. If ID 0 is selected, the indication (_:2311:304) Blocked no V selected is set. The synchrocheck is blocked. If you have activated the parameter (_:5071:108) Direct close command, unsynchronized switching is still possible.

7.5.6 Sequence of Functions

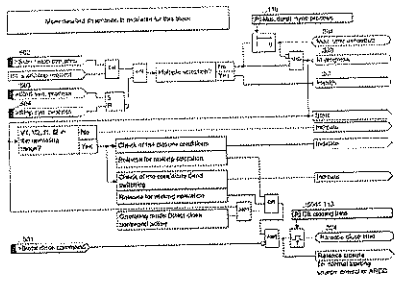


Figure 7-75 Sequence of Functions

Start

The synchronization stage must be started to check the closing conditions. The synchronization stage can be started device-internally by the controller or externally, via binary input signals (see section 7.5.12 Interaction with Control and External Triggering).

At the start, the system checks whether there is a multiple selection by the synchronization stage (see section Monitoring in chapter 7.5.4 General Functionality). If this is the case, the process is terminated. After a successful start, the indication In progress is issued and the supervision time for the maximum duration of the synchronization process (parameter Max.durat. sync. process) is started. The system also checks whether the voltages and frequencies are in the operating range (see section [illegible] 7.5.4 General Functionality). If this is not the case, the closing conditions are not checked.

Checking the Closing Conditions, Closure

After starting, the parameterized closing conditions are checked depending on the operating mode selected (see Chapter 7.5.8 Closing Conditions for the Synchronous/Asynchronous Stage Type to 7.5.11 Direct Close Command). Every condition fulfilled is explicitly indicated here. Conditions not fulfilled are also indicated. If all conditions are fulfilled, the synchronization stage sets the indication All sync. condit. OK. This indication is active until all conditions are fulfilled. The further behavior for issuing the release for closing depends on the type of the stage (see Chapters 7.5.7 Closing Conditions for the Synchrocheck Stage Type and 7.5.8 Closing Conditions for the Synchronous/Asynchronous Stage Type). The release is signaled via the Release close cmd. indication. This indication is active for [illegible] ms. With an internal start, the controller executes the actual closure, depending on the starting source.

Switching to Dead Line/Busbar

If operating modes for switching to dead parts of an electrical power system are configured, the associated conditions are also checked after the start (see chapter 7.5.10 Closing at De-Energized Line/Busbar). The fulfilled conditions are signaled. An adjustable supervision time is started after the closure conditions are fulfilled (parameter CB make time). If the conditions remain valid until expiry of the time, the function gives the release for closure after expiry of the time.

Direct Closing Command

If the Direct close command operation is active, the function instantaneously initiates the release for closure after the successful start (see chapter 7.5.11 Direct Close Command). A combination of direct close command with other release conditions is not advisable, as these conditions are bypassed by the direct close command.

End of the Process

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

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

Blocking Closure

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

7.5.7 Closing Conditions for the Synchrocheck Stage Type

Checking Closing Conditions

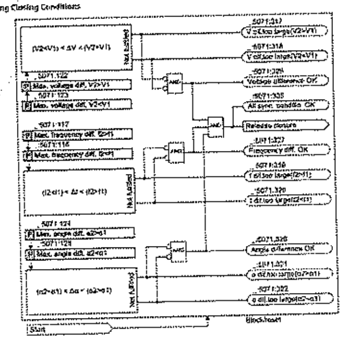


Figure 7-76 Closing Conditions for the Synchrocheck Function

With this operating mode, the values ΔV, Δf, and Δα are checked before connecting the 2 parts of the electrical power system. The indication All sync. condit. OK signals that the setting values (conditions) have been reached and that the release for closure has been given (see Checking the Closing Conditions, Closure in section 7.5.6 Sequence of Functions).

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

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

With the Expanded df/dt options stage type configured and an activated (_:140) Limit dfdiff/dt for sync. cp parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter (_:141) Max. value dfdiff/dt sync) is exceeded, the indication (_:322) df/dt too large is issued.

7.5.8 Closing Conditions for the Synchronous/Asynchronous Stage Type

A distinction according to synchronous and asynchronous systems can be made with this type of stage. If galvanically coupled systems are switched in parallel, synchronous systems are present. A typical characteristic for synchronous systems is equality of frequency (Δf ≈ 0). If the frequency difference falls below the setting value of the f-threshold ASYN<->SYN parameter, synchronous systems are to be assumed. If the frequency difference exceeds the setting value of the f-threshold ASYN<->SYN parameter, asynchronous systems are to be assumed. This status occurs in galvanically isolated systems, for example.

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

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

Checking the Closing Conditions in Synchronous Systems

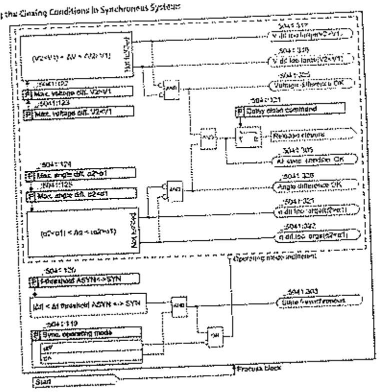


Figure 7-77 Closing Conditions when Switching Synchronous Systems

The frequency difference is very low in the synchronous systems operating mode, it is below the threshold value f-threshold ASYN<->SYN. The status is signaled via the State f-synchronous indication. The parameters ΔV and Δα are checked for issuing an activation release (see Figure 7-78). The indication All sync. conditions OK signals that both setting values (conditions) are reached. If the conditions remain fulfilled over the set time delay (parameter Delay close command), the release for closing is given (see also chapter 7.5.7 Closing Conditions for the Synchrocheck Stage Type).

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

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

With the Expanded data-f options stage type configured and an activated (_:142) Limit dfdiff/dt for async. op parameter, the frequency difference rate of change is also checked. If the permissible frequency change rate (parameter (_:143) Max. value dfdiff/dt async) is exceeded, the indication (_:329) 4 fdiff/dt too large is generated.

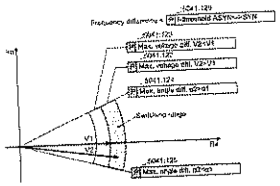


Figure 7-78 Connecting Under Synchronous System Conditions

Checking Closing Conditions in Asynchronous Systems

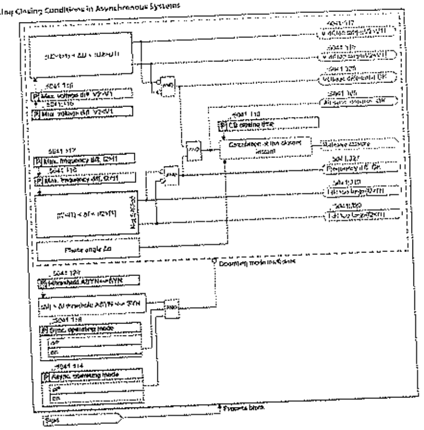


Figure 7-79 Closing Conditions when Switching Asynchronous Systems

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

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

Figure 7-80 shows the setting parameters for synchronous and asynchronous conditions in the V-f diagram. The frequency range is very narrow owing to the functional principle in the case of synchronous systems.

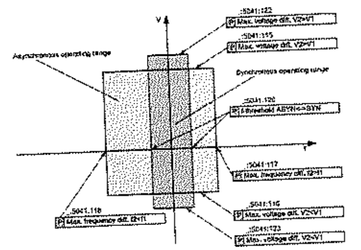


Figure 7-80 Operating Range Under Synchronous and Asynchronous Conditions for Voltage (V) and Frequency (f)

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

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

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

- Compensation for low-frequency oscillations
  If you activate this option (parameter (_:150) Suppr. freq. oscillations), low-frequency oscillations, for example, as a consequence of power swings in the range of 0.8 Hz to 1.6 Hz are detected and smoothed. This stabilizes the release checks in the presence of frequently changing deviations of upper and lower limits for the specified frequency threshold values. This option affects the frequency check of the Synchrocheck stage types and the synchronous operating mode of the Synchronous/Asynchronous stage type. It does not affect the asynchronous operating mode.
  In the example of the following figure, the synchrocheck function would initiate energization, if the allowed frequency difference was set to 10 mHz without the parameter Suppr. freq. oscillations as soon as the frequency f2 enters the 10-mHz band. If the parameter Suppr. freq. oscillations is activated, energization is not initiated, since the average value of f2 is outside the band.

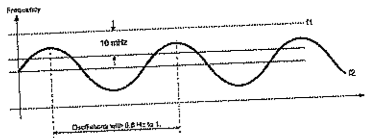


Figure 7-81 Example: Frequency Difference between the Constant Frequency f1 and the Sinusoidal Oscillating Frequency f2

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

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

7.5.10 Closing at De-Energized Line/Busbar

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

If the measured voltage is less than the threshold V1, V2 without voltage, the zero potential of the part of the electrical power system is detected. In this case, all phases are compared to the parameter V1, V2 without voltage. The energized side must be in the defined operating range with respect to voltage and frequency (see chapter 7.5.4 General Functionality) and all phases must exceed the threshold V1, V2 with voltage.

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

Settings	Description
Close cmd. at V1> & V2<	Closing release under the condition that the part V_1 of the power system is energized and the part of the electrical power system V_2 is de-energized.
Close cmd. at V1< & V2>	Closing release under the condition that the part V_1 of the power system is de-energized and the part of the electrical power system V_2 is energized.

Settings	Description
Close cmd. at V1< & V2<	Closing release provided that both V_1 and V_2 are de-energized.

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

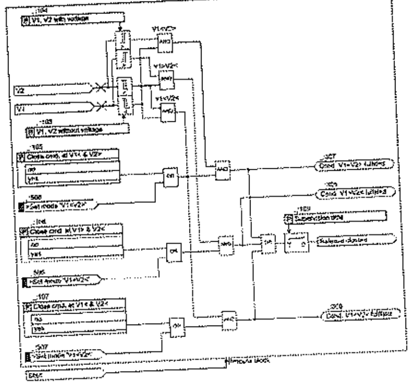


Figure 7-82 Release Conditions for Switching to De-Energized Line/Busbar

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

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

7.5.11 Direct Close Command

[illegible]

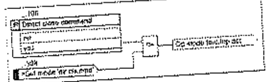


Figure 7-83 Activation of the Operating Mode Direct Close Command

The operating mode **Direct close command** function initiates a closure release without any testing [illegible]

[illegible]

7.5.12 Interaction with Control and External Triggering

With Control

The control and synchronization function are always located in a function group Circuit breaker. [illegible]

[illegible]

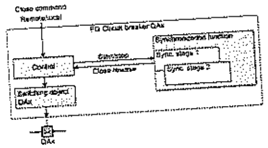


Figure 7-84 Interaction of the Control with the Synchronization Function

With External Control

[illegible]

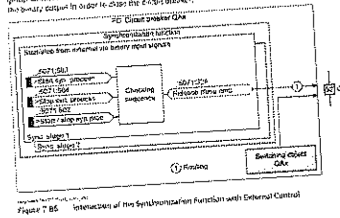


Figure 7-85 Interaction of the Synchronization Function with External Control

7.5.13 Application and Setting Notes (General)

Stage-Type Selection

The following 2 types of stage are available:

Stage Type	Application
Synchrocheck stage	Select this type of stage to issue, for example, an additional release during an manual reclosing for safety reasons. With this type, the variables ΔV, Δf and Δα are checked before connecting the 2 parts of the power system.
Synchronous/asynchronous stage	[illegible]

Configuration of the Voltages V1 (Reference Side) and V2

[illegible]

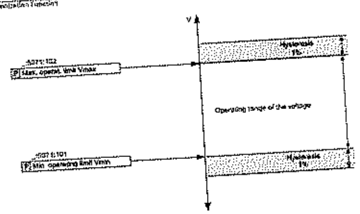
Parameter: Min. operating limit Vmin, Max. operat. limit Vmax

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

[illegible]

NOTE

[illegible]



[illegible]

Parameter: Max. durat. sync.process

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

[illegible]

Parameter: Voltage adjustment

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

[illegible]

Parameter: Angle adjust. (transform.)

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

[illegible]

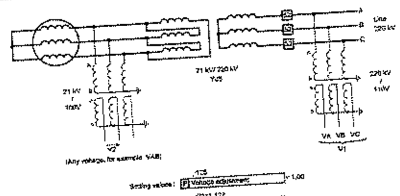


Figure 7-86 Transformer Between the Measuring Points

[illegible]

Parameter: CB make time

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

[illegible]

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

7.5.14 Application and Setting Notes (Synchrocheck)

Parameter: Maximum Differential Values of Voltage, Frequency and Angle

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

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

[illegible]

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

7.5.15 Application and Setting Notes (Synchronous/Asynchronous Closure)

Parameter: Synchronous operating mode, Asynchronous operating mode

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

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

The following combination options are possible:

Sync. operating mode	Async. operating mode	Description
on	on	[illegible] If you wish to interconnect galvanically isolated systems, then select this operating mode.
off	on	Regardless of the frequency difference [illegible] the operating mode active is exclusively asynchronous. [illegible]
on	off	Use this operating mode for galvanically connected systems. Closure is only possible with synchronous systems [illegible]

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

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

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

For information, see Parameter for synchronous operation

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

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

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

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

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

Parameter: Switchover between synchronous and asynchronous operation

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

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

Siemens recommends using the default setting of 0.01 Hz.

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

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

NOTE

For reasons of safety, the releases have been deactivated in the default setting and are therefore at no. Even if you wish to apply one of these operating modes, Siemens recommends leaving the setting at no for reasons of safety. Set the operating mode only dynamically via the assigned binary input signal (for example >Op.mode V1<V2> (see also Figure 7-87)). This prevents one of these operating modes from being incorrectly activated statically thereby resulting in an incorrect switching.

Parameter: Close cmd. at V1< & V2>

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

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

Parameter: Close cmd. at V1> & V2<

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

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

Parameter: Close cmd. at V1< & V2<

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

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

Parameter: V1, V2 with voltage

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

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

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

Parameter: V1, V2 without voltage

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

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

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

Parameter: Supervision time

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

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

Parameter: Direct close command

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

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

NOTE

For safety reasons, Siemens recommends leaving the setting at no. If a direct close command is necessary, Siemens recommends only using this operating mode dynamically via the binary input signal >Op. mode "dir.cls.cmd" (see also Figure 7-87). This prevents this operating mode from being incorrectly activated statically thereby resulting in an incorrect switching.

7.5.17 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:127	General:Angle adjust. (transform.)		-179.0° to 180.0°	0.0°
General				
_:5071:1	Synchrocheck 1:Mode		• off • on • test	off
_:5071:101	Synchrocheck 1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5071:102	Synchrocheck 1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5071:110	Synchrocheck 1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5071:108	Synchrocheck 1:Direct close command		• no • yes	no
_:5071:126	Synchrocheck 1:Voltage adjustment		0.500 to 2.000	1.000
De-energized switch.				
_:5071:105	Synchrocheck 1:Close cmd. at V1< & V2>		• no • yes	no
_:5071:106	Synchrocheck 1:Close cmd. at V1> & V2<		• no • yes	no
_:5071:107	Synchrocheck 1:Close cmd. at V1< & V2<		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:5071:103	Synchrocheck 1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5071:104	Synchrocheck 1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5071:109	Synchrocheck 1:Supervision time		0.00 s to 60.00 s	0.1 s
Synchr. conditions				
_:5071:122	Synchrocheck 1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5071:123	Synchrocheck 1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5071:117	Synchrocheck 1:Max. frequency diff. f2>f1		0.000 Hz to 2.000 Hz	0.100 Hz
_:5071:118	Synchrocheck 1:Max. frequency diff. f2<f1		0.000 Hz to 2.000 Hz	0.100 Hz
_:5071:124	Synchrocheck 1:Max. angle diff. α2>α1		0° to 90°	10°
_:5071:125	Synchrocheck 1:Max. angle diff. α2<α1		0° to 90°	10°
General				
_:5041:1	Sychr./Async.1:Mode		• off • on • test	off
_:5041:101	Sychr./Async.1:Min. operating limit Vmin		0.300 V to 340.000 V	90.000 V
_:5041:102	Sychr./Async.1:Max. operat. limit Vmax		0.300 V to 340.000 V	110.000 V
_:5041:110	Sychr./Async.1:Max.durat. sync.process		0.00 s to 3600.00 s; ∞	30.00 s
_:5041:108	Sychr./Async.1:Direct close command		• no • yes	no
_:5041:126	Sychr./Async.1:Voltage adjustment		0.500 to 2.000	1.000
De-energized switch.				
_:5041:105	Sychr./Async.1:Close cmd. at V1< & V2>		• no • yes	no
_:5041:106	Sychr./Async.1:Close cmd. at V1> & V2<		• no • yes	no
_:5041:107	Sychr./Async.1:Close cmd. at V1< & V2<		• no • yes	no
_:5041:103	Sychr./Async.1:V1, V2 without voltage		0.300 V to 170.000 V	5.000 V
_:5041:104	Sychr./Async.1:V1, V2 with voltage		0.300 V to 340.000 V	80.000 V
_:5041:109	Sychr./Async.1:Supervision time		0.00 s to 60.00 s	0.1 s
Asynchr. op.mode				
_:5041:114	Sychr./Async.1:Async. operating mode		• off • on	on
_:5041:113	Sychr./Async.1:CB make time		0.01 s to 0.60 s	0.06 s

Addr.	Parameter	C	Setting Options	Default Setting
_:5041:115	Sychr./Async.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:116	Sychr./Async.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:117	Sychr./Async.1:Max. frequency diff. f2>f1		0.000 Hz to 4.000 Hz	0.100 Hz
_:5041:118	Sychr./Async.1:Max. frequency diff. f2<f1		0.000 Hz to 4.000 Hz	0.100 Hz
Synchr. op.mode				
_:5041:119	Sychr./Async.1:Sync. operating mode		• off • on	on
_:5041:120	Sychr./Async.1:f-threshold ASYN<->SYN		0.010 Hz to 0.200 Hz	0.010 Hz
_:5041:122	Sychr./Async.1:Max. voltage diff. V2>V1		0.000 V to 170.000 V	5.000 V
_:5041:123	Sychr./Async.1:Max. voltage diff. V2<V1		0.000 V to 170.000 V	5.000 V
_:5041:124	Sychr./Async.1:Max. angle diff. α2>α1		0° to 90°	10°
_:5041:125	Sychr./Async.1:Max. angle diff. α2<α1		0° to 90°	10°
_:5041:121	Sychr./Async.1:Delay close command		0.00 s to 60.00 s	0.00 s
dfdiff/dt limitation				
_:140	Adv. options:Limit dfdiff/dt for sync. op.		• 0 • 1	false
_:141	Adv. options:Max. value dfdiff/dt syn		0.010 Hz/s to 0.250 Hz/s	0.010 Hz/s
_:142	Adv. options:Limit dfdiff/dt for async. op.		• 0 • 1	false
_:143	Adv. options:Max. value dfdiff/dt asyn		0.050 Hz/s to 0.500 Hz/s	0.050 Hz/s
Freq. oscillations				
_:150	Adv. options:Supp. frequ. oscillations		• 0 • 1	false
_:151	Adv. options:Max. diff. f threshold		0.000 Hz to 0.100 Hz	0.000 Hz

7.5.18 Information List

No.	Information	Data Class (Type)	Type
Measurements			
_:2311:301	General:[illegible]	SPS	O
_:2311:304	General:[illegible]	SPS	O
_:2311:329	General:f1	MV	O
_:2311:330	General:f2	MV	O
_:2311:331	General:V1	MV	O
_:2311:332	General:V2	MV	O
_:2311:333	General:dV	MV	O

No.	Information	Data Class (Type)	Type
_:2311:401	General:df	MV	O
_:2311:302	General:dα	MV	O
Synchrocheck 1			
_:5071:81	Synchrocheck 1:>Block stage	SPS	I
_:5071:501	Synchrocheck 1:>Selection	SPS	I
_:5071:502	Synchrocheck 1:>Start / stop sync. proc.	SPS	I
_:5071:503	Synchrocheck 1:>Start sync. process	SPS	I
_:5071:504	Synchrocheck 1:>Stop sync. process	SPS	I
_:5071:506	Synchrocheck 1:>Op. mode V1<V2>	SPS	I
_:5071:505	Synchrocheck 1:>Op. mode V1>V2<	SPS	I
_:5071:507	Synchrocheck 1:>Op. mode V1<V2<	SPS	I
_:5071:508	Synchrocheck 1:>Op. mode dir.cl.cmd	SPS	I
_:5071:509	Synchrocheck 1:>Block close command	SPS	I
_:5071:54	Synchrocheck 1:Inactive	SPS	O
_:5071:52	Synchrocheck 1:Behavior	ENS	O
_:5071:53	Synchrocheck 1:Health	ENS	O
_:5071:328	Synchrocheck 1:In progress	SPS	O
_:5071:321	Synchrocheck 1:Release close cmd	SPS	O
_:5071:305	Synchrocheck 1:All sync. conditions OK	SPS	O
_:5071:325	Synchrocheck 1:Voltage difference OK	SPS	O
_:5071:326	Synchrocheck 1:Angle difference OK	SPS	O
_:5071:327	Synchrocheck 1:Frequency diff. OK	SPS	O
_:5071:307	Synchrocheck 1:Cond. V1>V2< fulfilled	SPS	O
_:5071:308	Synchrocheck 1:Cond. V1<V2> fulfilled	SPS	O
_:5071:306	Synchrocheck 1:Cond. V1<V2< fulfilled	SPS	O
_:5071:309	Synchrocheck 1:Frequency f1 > fmax	SPS	O
_:5071:310	Synchrocheck 1:Frequency f1 < fmin	SPS	O
_:5071:311	Synchrocheck 1:Frequency f2 > fmax	SPS	O
_:5071:312	Synchrocheck 1:Frequency f2 < fmin	SPS	O
_:5071:313	Synchrocheck 1:Voltage V1 > Vmax	SPS	O
_:5071:314	Synchrocheck 1:Voltage V1 < Vmin	SPS	O
_:5071:315	Synchrocheck 1:Voltage V2 > Vmax	SPS	O
_:5071:316	Synchrocheck 1:Voltage V2 < Vmin	SPS	O
_:5071:317	Synchrocheck 1:V diff too large(V2>V1)	SPS	O
_:5071:318	Synchrocheck 1:V diff too large(V2<V1)	SPS	O
_:5071:319	Synchrocheck 1:f diff too large(f2>f1)	SPS	O
_:5071:320	Synchrocheck 1:f diff too large(f2<f1)	SPS	O
_:5071:321	Synchrocheck 1:α diff too large(α2>α1)	SPS	O
_:5071:322	Synchrocheck 1:α diff too large(α2<α1)	SPS	O
_:5071:304	Synchrocheck 1:Max. time exceeded	SPS	O
_:5071:323	Synchrocheck 1:Setting error	SPS	O
Synchr./Asyncr. 1			
_:5041:81	Sychr./Async.1:>Block stage	SPS	I
_:5041:501	Sychr./Async.1:>Selection	SPS	I
_:5041:502	Sychr./Async.1:>Start / stop sync. proc.	SPS	I
_:5041:503	Sychr./Async.1:>Start sync. process	SPS	I

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No.	Information	Data Class (Type)	Type
		SPS	I
_5041:500	Sychr./Async.1:>Adjust sync. process	SPS	I
_5041:506	Sychr./Async.1:>Op. mode V1>V2>	SPS	I
_5041:505	Sychr./Async.1:>Op. mode V1<V2>	SPS	I
_5041:507	Sychr./Async.1:>Op. mode V1<V2<	SPS	I
_5041:508	Sychr./Async.1:>Op. mode 'dir. close'	SPS	I
_5041:501	Sychr./Async.1:>Block close command	SPS	O
_5041:54	Sychr./Async.1:Inactive	ENS	O
_5041:52	Sychr./Async.1:Behavior	ENS	O
_5041:53	Sychr./Async.1:Health	SPS	O
_5041:326	Sychr./Async.1:In progress	SPS	O
_5041:324	Sychr./Async.1:Release close cmd.	SPS	O
_5041:305	Sychr./Async.1:All sync. condition. OK	SPS	O
_5041:303	Sychr./Async.1:State f synchronism	SPS	O
_5041:325	Sychr./Async.1:Voltage difference OK	SPS	O
_5041:326	Sychr./Async.1:Angle difference OK	SPS	O
_5041:327	Sychr./Async.1:Frequency diff. OK	SPS	O
_5041:307	Sychr./Async.1:Cond. V1>V2< fulfilled	SPS	O
_5041:306	Sychr./Async.1:Cond. V1<V2> fulfilled	SPS	O
_5041:308	Sychr./Async.1:Cond. V1<V2< fulfilled	SPS	O
_5041:309	Sychr./Async.1:Frequency f1 > fmax	SPS	O
_5041:310	Sychr./Async.1:Frequency f1 < fmin	SPS	O
_5041:311	Sychr./Async.1:Frequency f2 > fmax	SPS	O
_5041:312	Sychr./Async.1:Frequency f2 < fmin	SPS	O
_5041:313	Sychr./Async.1:Voltage V1 > Vmax	SPS	O
_5041:314	Sychr./Async.1:Voltage V1 < Vmin	SPS	O
_5041:315	Sychr./Async.1:Voltage V2 > Vmax	SPS	O
_5041:316	Sychr./Async.1:Voltage V2 < Vmin	SPS	O
_5041:317	Sychr./Async.1:V diff. too large(V2>V1)	SPS	O
_5041:318	Sychr./Async.1:V diff. too large(V2<V1)	SPS	O
_5041:319	Sychr./Async.1:f diff. too large(f2>f1)	SPS	O
_5041:320	Sychr./Async.1:f diff. too large(f2<f1)	SPS	O
_5041:321	Sychr./Async.1:α diff. too large(α2>α1)	SPS	O
_5041:322	Sychr./Async.1:α diff. too large(α2<α1)	SPS	O
_5041:304	Sychr./Async.1:Max. time exceeded	SPS	O
_5041:323	Sychr./Async.1:Setting error		

7.6 User-Defined Function Block [Control]

7.6.1 Overview of Functions

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

7.6.2 Function Description

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

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

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

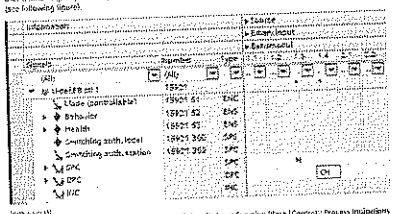

Figure 7-87 Information Routing with Inserted User-Defined Function Block [Control]: Process Indications and Some Individual Indications

7.6.3 Application and Setting Notes

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

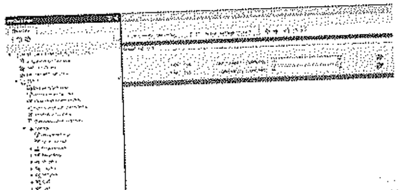

Figure 7-88 Parameterization Options of the User-Defined Function Block [Control]

Parameter: Check switching authority

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

With the Check switching authority parameter, you determine whether the command source of switching commands must be checked (see chapter 7.5.2 Command Checks and Switchgear Interlocking Protection).

Parameter: Check if pos. is reached

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

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

7.6.4 Settings

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

7.6.5 Information List

No.	Information	Data Class (Type)	Type
U-def.FB ctl.#			
_:51	U-def.FB ctl.#:Mode (controllable)	ENC	C
_:52	U-def.FB ctl.#:Behavior	ENS	O
_:53	U-def.FB ctl.#:Health	ENS	O
_:301	U-def.FB ctl.#:Switching auth. local	SPS	O
_:302	U-def.FB ctl.#:Switching auth. station	SPC	C

7.7 CFC-Chart Settings

7.7.1 Overview of Functions

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

7.7.2 Function Description

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

NOTE

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

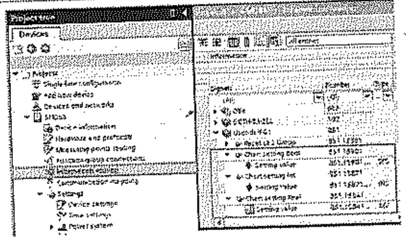

Figure 7-89 CFC-Chart Parameters within Information Routing

7.7.3 Application and Setting Notes

Parameter: Chart setting Bool

- Default setting Chart setting Bool = false

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

Parameter: Chart setting Int

- Default setting Chart setting Int = 10

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

Parameter: Chart setting Real

- Default setting Chart setting Real = 100,000

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

7.7.4 Settings

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

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

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

7.7.5 Information List

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

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

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

7.8 Transformer Tap Changers

7.8.1 Function Description

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

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

The following options are provided for control:

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

If the tap changer reaches the end positions, the control function issues the (_:301) End higher pos. reached or (_:302) End lower pos. reached indication.

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

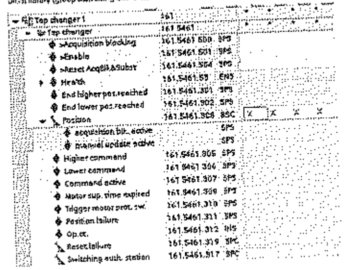

Figure 7-90 Tap Changer Functionality in the DIGSI Information Matrix

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

You can find more information in chapter 7.8.2 Application and Setting Notes.

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

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Example

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

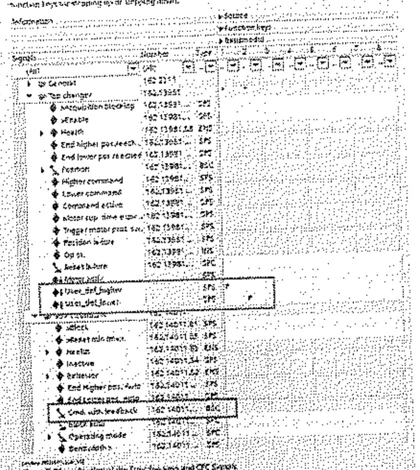

Figure 7-91 Routing of the Function Keys and CFC Signals

To use the function keys, you create 2 user-defined single-point indications (SPS). These are used for the function keys (for example, »F1«, higher function key and »F2«, lower function key) and as the input signals for the appropriate CFC blocks. In addition, you must use the controllable Cmd. with feedback for the CFC chart.

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

- 1 means step up
- 0 means step down

Figure 7-92 CFC Chart

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

Motor Supervision Time

The runtime of the motor drive can be monitored from the device. This function is used to identify failures of the motor drive during switching and to trip actions if necessary. To use the Motor supervision time, you must route the motor sliding contact (highest binary input) and set the proper motor runtime. The motor sliding contact is active until the tap changer has reached the new position. This time is compared to the Motor supervision time. If the new tap position is not reached within the motor runtime, the Motor sup. time expired indication is set. The Trigger motor prot. sw. indication with which the motor can be switched off is output after 1.5 s.

Adjusting-Command Monitoring

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

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

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

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

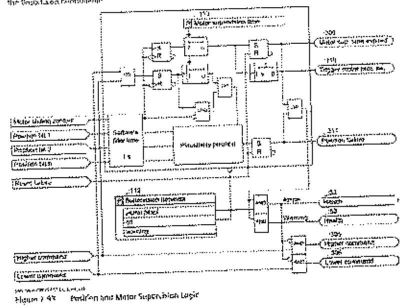

Figure 7-93 Position and Motor Supervision Logic

Supervision Behavior

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

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

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

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

Operating Meter

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

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

7.8.2 Application and Setting Notes

Parameters of the Transformer Tap Changer Function Group

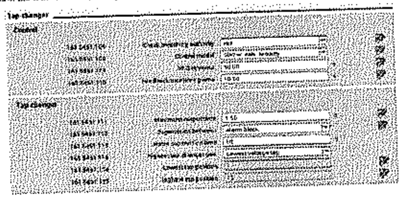

Figure 7-94 Parameters of the Tap Changer

NOTE

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

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

Parameter: Check switching authority

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

Parameter: Control model

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

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

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

Parameter: SBO time-out

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

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

Parameter: Feedback monitoring time

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

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

Parameter: Maximum output time

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

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

Parameter: Supervision behavior

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

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

Parameter: Motor supervision time

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

After the motor supervision time has elapsed, the indication Motor sup. time expired is displayed. Additional information can be found in the margin title Motor Supervision Time, Page 1268. The range of values extends from 5 s to 100 s.

Parameter: Highest tap changer pos.

- Default setting (_:114) Highest tap changer pos. = Lowest voltage tap

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

Additional Settings (Properties Dialog Position)

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

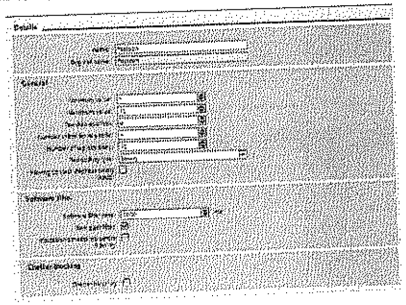

Figure 7-95 Properties Dialog

Parameter: Minimum value

- Default setting Minimum value = 1

Parameter: Maximum value

- Default setting Maximum value = 15

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

Parameter: Tap-display offset

- Default setting Tap-display offset = 0

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

Parameter: Number of bits f. tap code

- Default setting Number of bits f. tap code = 4

With the Number of bits f. tap code parameter, set the number of bits you need for coding the transformer taps. The number is dependent on the selected Encoding and on the Moving contact. For example, you need 3 bits for 7 binary-encoded transformer taps. The range of values extends from 2 to 32.

ВЯРНО С ОРИГИНАЛА

8.11

Parameter: Number of tap positions

- Default setting Number of tap positions = 19

With the Number of tap positions parameter, you set the number of transformer taps. The range of values extends from 2 to 127, the output of the tap position is limited from -63 to +64. If the number of taps is ≥ 63, set the parameter Tap-display offset so that the tap position is within the range of -63 to +63.

Parameter: Tap-coding type

- Default setting Tap-coding type = binary

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

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

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

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

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

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

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

> **NOTE**
>
> If the binary inputs used for encoding are all inactive, this indicates an invalid tap position (regardless of the display offset). For an invalid tap position, the display shows the position — or -64 with quality invalid. The exception is BCD with sign, see Routing of the Binary Inputs (Tap Coding Type: BCD with Sign), Page 1224

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

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

The following table shows the routing of 3 binary inputs (BI 1 to BI 3) with 4 transformer tap positions designated 3 to 6. BI4 is the moving contact. The encoding is in binary.

Table 7-25 Routing of the Binary Inputs (Tap Coding Type: Binary)

	Example					
	BI1	BI2	BI3	BI4	BI5	BI6
Tap changer	X	X	X	X		

	Example					
Meaning	Bit 1	Bit 2	Bit 3	Moving contact		
Tap = 5	1	0	[illegible]			

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

Tap-coding type:	Binary
Number of tap positions:	4
Number of bits f. tap code:	3
Tap-display offset:	2
Moving contact (highest binary input):	Yes

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

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

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

Table 7-26 Routing of the Binary Inputs (Tap Coding Type: BCD with Sign)

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

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

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

Routing the Tap Position to Binary Outputs

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

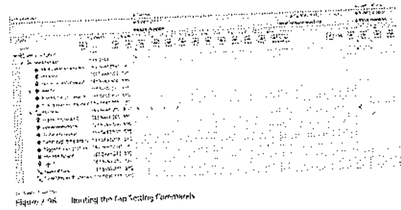

Figure 7-96 Routing the Tap Setting Commands

Parameter: Moving contact (highest binary input)

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

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

Parameter: Software filter time

- Default setting Software filter time = 1000 ms

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

Parameter: Retrigger filter

- Default setting Retrigger filter = yes

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

Parameter: Indication timestamp before filtering

- Default setting Indication timestamp before filtering = no

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

Parameter: Chatter blocking

- Default setting Chatter blocking = no

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

7.8.3 Settings (Properties Dialog)

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

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

> **NOTE**
>
> You can find more detailed information on the process monitor in chapter 5.5.4 Process Monitor (FG Lines).

7.8.4 Settings

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

Addr.	Parameter	C	Setting Options	Default Setting
Cmd with feedback				
_:117	Tap changer:SI/Subst.-related sw.auth.		• 0 • 1	false
_:118	Tap changer:Specific sw. authorities		• 0 • 1	true
_:119	Tap changer:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:120	Tap changer:Num. of specific sw.auth.		2 to 5	2
_:121	Tap changer:Multiple specific sw.auth.		• 0 • 1	false

7.8.5 Information List

No.	Information	Data Class (Type)	Type
Tap changer			
_:500	Tap changer:>Acquisition blocking	SPS	I
_:501	Tap changer:>Enable	SPS	I
_:502	Tap changer:>Sw. authority local	SPS	I
_:503	Tap changer:>Sw. authority remote	SPS	I
_:505	Tap changer:>Sw. mode interlocked	SPS	I
_:510	Tap changer:>Sw. mode non-interl.	SPS	I
_:504	Tap changer:Reset AcqBlk&Subst	SPS	I
_:53	Tap changer:Health	ENS	O
_:301	Tap changer:End higher pos. reached	SPS	O
_:302	Tap changer:End lower pos. reached	SPS	O
_:308	Tap changer:Position	BSC	C
_:305	Tap changer:Higher command	SPS	O
_:306	Tap changer:Lower command	SPS	O
_:307	Tap changer:Command active	SPS	O
_:309	Tap changer:Motor sup. time exceed.	SPS	O
_:310	Tap changer:Trigger motor prot. sw.	SPS	O
_:311	Tap changer:Position failure	SPS	O
_:312	Tap changer:Op.ct.	INS	O
_:313	Tap changer:Switching authority	ENS	O
_:314	Tap changer:Switching mode	ENS	O
_:315	Tap changer:Reset failure	SPC	C
_:317	Tap changer:Switching auth. station	SPC	C
_:320	Tap changer:Enable sw. auth. 1	SPC	C
_:321	Tap changer:Enable sw. auth. 2	SPC	C
_:322	Tap changer:Enable sw. auth. 3	SPC	C
_:323	Tap changer:Enable sw. auth. 4	SPC	C
_:324	Tap changer:Enable sw. auth. 5	SPC	C

7.9 Voltage Controller

7.9.1 Overview of Functions

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

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

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

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

7.9.2 Structure of the Function

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

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

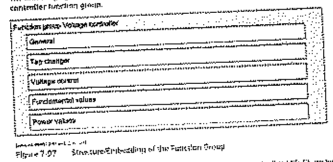

Figure 7-97 Structure/Embedding of the Function Group

The functions General (GAPC), Tap changer (YLTC), and Voltage controller (ATCC) are logical node points in IEC 61850-7-4.

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

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The function group has interfaces to the following measuring points:

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

Optionally, you can assign the tap changer to a Transformer side function group. In this way, the current of the upper-voltage side is also monitored and the differential protection pickup blocks the voltage controller automatically.

Figure 7-98 shows these interfaces as a block structure.

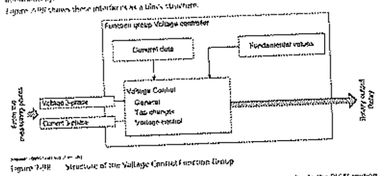

Figure 7-98 Structure of the Voltage Control Function Group

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

7.9.3 Function Description

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

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

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

This function is designed to control the following:

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

The control operation is based on a step by step principle. To move the tap changer one position higher or lower, a single control pulse is issued to the motor drive mechanism of the tap changer. The length of the control pulse can be set over a large range so as to handle the very different types of tap-changer drives. The

control pulse is issued if the measured voltage deviates from the set reference value by more than the preset voltage range for more than a given time period.

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

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

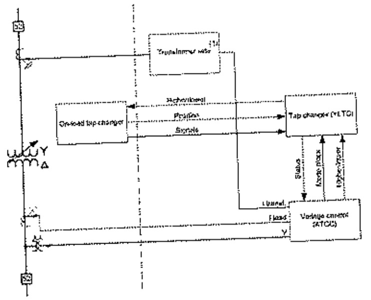

Figure 7-99 Voltage Controller Constellation for Two-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

(1) Only if a transformer side is present

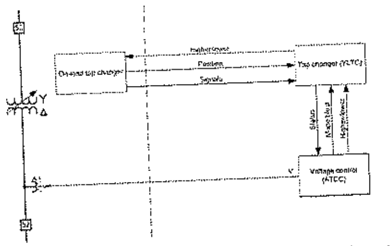

Figure 7-100 Voltage Controller Constellation for Two-Winding Transformers without Current Measurement

Three-Winding Transformers

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

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

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

For asymmetric load change, the voltage of the transformer side into which the larger load current flows is controlled. The respective uncontrolled voltage is monitored for undervoltage and overvoltage in contrast to overvoltage on the controlled side. For overvoltage on the uncontrolled side, the higher impulse is blocked and no fast step down to a lower tap occurs. In case of undervoltage on the uncontrolled side, the lower commands are blocked if this behavior is activated for undervoltage supervision.

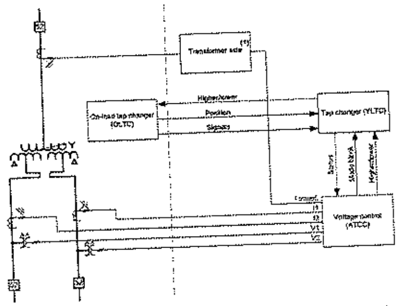

Figure 7-101 Voltage Controller Constellation for Three-Winding Transformers with Current Measurement for Load Compensation at the End of the Line

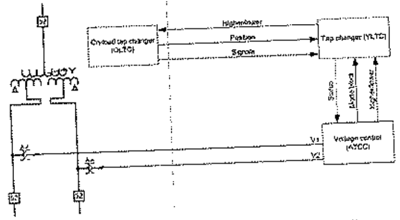

Figure 7-102 Voltage Controller Constellation for Three-Winding Transformers without Current Measurement

Grid Coupling Transformers

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

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

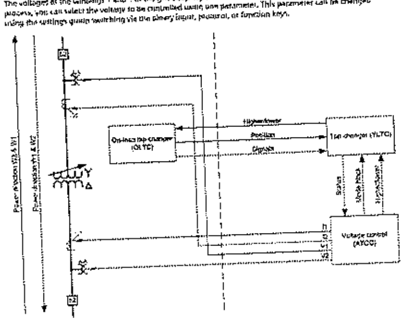

Figure 7-103 Voltage Controller Constellation for Grid Coupling Transformers

On-Load Tap Changer

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

Tap Changer

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

You can find more information in chapter 7.9.4 Application and Setting Notes.

Voltage Controller

The Voltage controller function controls the voltage within the bandwidth and within the set voltage limits.

Using the Mode parameter, you can turn the voltage controller on or off or set it for test mode.

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

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

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

Three-Winding Transformer Voltage Controller

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

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

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

Grid Coupling Transformer Voltage Controller

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

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

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

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

Logic of the Function

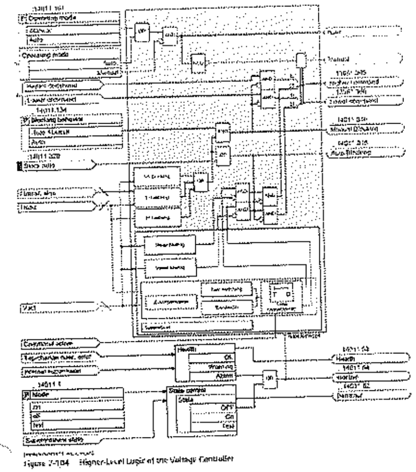

Figure 7-104 Higher-Level Logic of the Voltage Controller

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

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

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

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

You can switch over the settings groups via the following alternatives:

- via the on-site operation panel directly on the device
- via an online DIGSI connection to the device
- via binary inputs
- via a communication connection to a substation automation technology (IEC 60870-5-103, IEC 61850)

You can find more information in chapter 5.10.1 Settings-Group Switching.

Control Deviation

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

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

D = Control deviation

Bandwidth

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

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

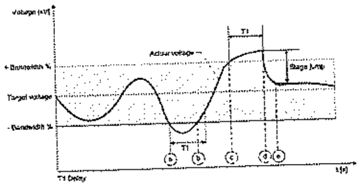

Figure 7-105 Actual Voltage Curve during Control Deviation

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

Linear, Inverse Control Response

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

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

The set inverse characteristic curve is a function of the parameter T1 delay. The characteristic curves arising for different settings of the time T1 delay are shown in chapter 7.9.4 Application and Setting Notes, under the Parameter: T1 characteristic.

Control Response with Zero Potential or Voltage Recovery

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

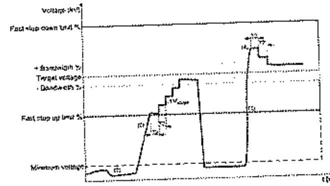

Figure 7-106 Actual Voltage Curve during Control with T2

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

Control Response in the Event of Larger Voltage Deviations

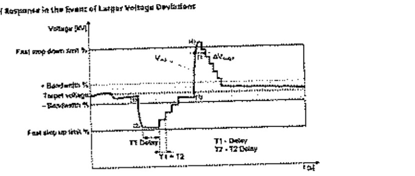

Figure 7-107 Actual Voltage Curve During Larger Control Deviations

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

Fast Step Up Mode and Fast Step Down Mode

The fast step down mode and the fast step up mode allow a fast reaction to abnormal voltage situations. Figure 7-107 shows such a situation at point (4). A fast step down mode occurs until the bandwidth has been reached. The step time between 2 consecutive lower commands results from the following 2 conditions:

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

The activity of the fast step down mode and the fast step up mode is displayed with the indications (_:14011:306) Fast Step Down active and (_:14011:307) Fast Step Up active.

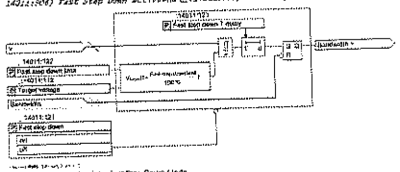

Figure 7-108 Logic of the Fast Step Down Mode

The fast step up mode operates in a similar fashion.

Function Supervision for Automatic Operation

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

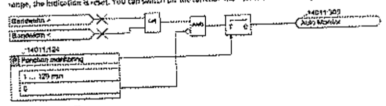

Figure 7-109 Logic of the Function Supervision for Automatic Operation

Phase Compensation

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

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

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

Z Compensation (LDC-Z)

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

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

You can find more information and the calculation in chapter 7.9.4 Application and Setting Notes.

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

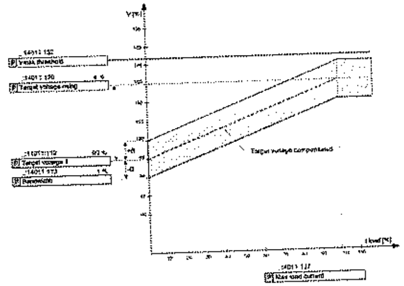

Figure 7-110 Control Characteristic with Z Compensation

X and R Compensation (LDC-XandR)

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

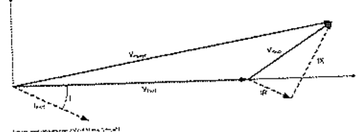

Figure 7-111 Phasor Diagram of the X and R Compensation

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

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

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

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

Limiting Values

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

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

Blockings

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

- Undervoltage
- Overcurrent, load current
- Overcurrent on one transformer side
- Undercurrent
- External blocking (binary input)
- Blocking command IEC/Client IEC 61850
- Blocking in the event of pickup of the transformer differential protection

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

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

By assigning the tap changer to the transformer side, you also arrange the current of the upper-voltage side. Perform this assignment in the appropriate Transformer side function group (see chapter 5.5.3 Function-Group Type Transformer Side). Here, you must use the tap changer of the voltage controller.

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

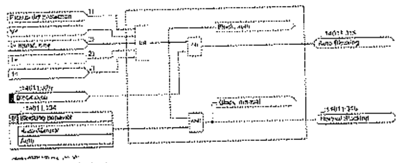

Figure 7-172 Logic Blockings

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

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

Additional Blockings for the Three-Winding Transformer Voltage Controller

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

Additional Blockings for the Grid-Coupling Transformer Voltage Controller

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

Functional Measured Values

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

Measured Values, Two-Winding Transformer

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

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

The functional measured values V max and V min can be reset with the input indication >Reset min./max. For the two-winding transformer, you can find the measured values under the following menu items of the device:

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

Measured Values, Three-Winding Transformer

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

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

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

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

Measured Values Grid Coupling Transformer

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

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

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

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

Fundamental Values and Power Measured Values

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

Table 7-27 and Table 7-28 show the total scope in case a 3-phase voltage measuring point is also connected.

Table 7-27 Possible Fundamental Values for the Voltage Controller Function Group

Fundamental Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary system
I_N	Measured zero-sequence current	A	A	Rated operating current of the primary system
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of the primary system/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltages	kV	V	Rated operating voltage of the primary system
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of the primary system/√3

Table 7-28 Possible Power Measured Values of the Voltage Controller Function Group

Power Measured Value		Primary	Secondary	% Referenced to
P_{total}	Active power (total power)	MW	W	Active power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q_{total}	Reactive power (total power)	Mvar	var	Reactive power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S_{total}	Apparent power (total power)	MVA	VA	Apparent power of the primary system $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1

7.9.4 Application and Setting Notes

Two-Winding Transformer: General

Parameter: Rated current

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

Parameter: Rated voltage

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

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

Three Winding Transformer and Grid Coupling Transformer: General

Winding 1

Parameter: Rated current

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

Parameter: Rated voltage

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

Winding 2

Parameter: Rated current

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

Parameter: Rated voltage

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

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

Tap Changer

The parameters of the tap changer inside the voltage controller correspond to those of the tap changer in chapter 7.6.2 Application and Setting Notes.

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

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

Voltage Controller

Parameter: Mode

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

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

Parameter: Operating mode

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

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

Only Three-Winding Transformer

Parameter: Winding selection

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

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

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

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

The function value Active winding shows the winding selection.

Only Grid Coupling Transformer

Parameter: Winding selection

- Default setting (_:16351:101) Winding selection = Winding 1

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

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

[*] Select Before Operate (SBO)

Controlling

Parameter: Check switching authority

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

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

Parameter: Control model

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

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

You can select one of the following settings:

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

Parameter: SBO time-out

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

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

Parameter: Feedback monitoring time

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

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

Parameter: Set point mode active

- Default setting (_:14011:160) Set point mode active = on

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

For the three-winding transformer, the address of the Set point mode active parameter is _:15601:172 while the address is _:16351:171 for the grid coupling transformer.

Only Two-Winding Transformer

Parameter: Number of target voltage

- Default setting (_:14011:156) Number of target voltage = 2

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

> **NOTE**
>
> Keep in mind that the parameter Number of target voltage cannot be influenced by way of the settings group switching.
>
> You can specify the target voltages (1 to 4) in primary, secondary, or in percent.
>
> For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1

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

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

Parameter: Target voltage 2

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

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

Parameter: Target voltage 3

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

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

Parameter: Target voltage 4

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

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

Only Three-Winding Transformer

Parameter: Number of target voltage

- Default setting (_:15601:156) Number of target voltage = 2

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

> **NOTE**
>
> Keep in mind that the parameter Number of target voltage cannot be influenced by way of the settings group switching.
>
> You can specify the target voltages (1 W1/2 to 4 W1/2) in primary, secondary, or in percent.
>
> For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

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

Parameter: Target voltage 1 w2

- Default setting (_:15601:146) Target voltage 1 w2 = 110.000 V

Parameter: Target voltage 2 w1

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

Parameter: Target voltage 2 w2

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

Parameter: Target voltage 3 w1

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

Parameter: Target voltage 3 w2

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

Parameter: Target voltage 4 w1

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

Parameter: Target voltage 4 w2

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

Only Grid Coupling Transformer

Parameter: Number of target voltage

- Default setting (_:16351:164) Number of target voltage = 2

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

> **NOTE**
>
> Keep in mind that the parameter Number of target voltage cannot be influenced by way of the settings group switching.
>
> You can specify the target voltages (1 W1/2 to 4 W1/2) in primary, secondary, or in percent.
>
> For the activation of the target voltages 1 to 4 via a binary input, you need a CFC chart.

Parameter: Target voltage 1 w1

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

Parameter: Target voltage 1 w2

- Default setting (_:16351:146) Target voltage 1 w2 = 110.000 V

Parameter: Target voltage 2 w1

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

Parameter: Target voltage 2 w2

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

Parameter: Target voltage 3 w1

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

Parameter: Target voltage 3 w2

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

Parameter: Target voltage 4 w1

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

Parameter: Target voltage 4 w2

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

Voltage Controller

Parameter: Bandwidth

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

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

Calculation of the Bandwidth

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

Calculation of the minimum bandwidth:

$$B[\%] \geq 0.5 \cdot \left(\frac{V_{rated,sec}}{V_{N,prim}} - \frac{V_{rated,sec}}{V_{(N-1),prim}} \right) \cdot V_{rated,sec} \cdot 100\,\% \cdot \frac{V_{max,prim}}{V_{rated,prim}}$$

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

Parameter: T1 characteristic

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

Parameter: T1 delay

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

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

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

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

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

T_1 = Parameter T1 delay

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

D = Control deviation

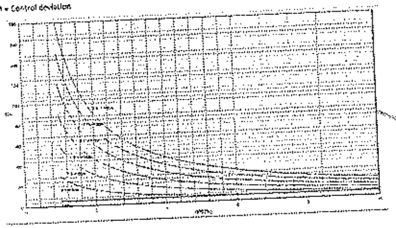

Figure 7-113 Inverse Control Characteristic

Parameter: T1 inverse Min

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

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

Parameter: T2 delay

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

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

Parameter: Regulate with T2 at start

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

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

For the three-winding transformer, the address of the Regulate with T2 at start parameter is _:15601:163 while the address is _:16351:163 for the grid coupling transformer.

Parameter: Fast step down

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

Parameter: Fast step down limit

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

Parameter: Fast step down T delay

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

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

Parameter: Fast step up

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

Parameter: Fast step up limit

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

Parameter: Fast step up T delay

- Default setting (_:120) Fast step up T delay = 3.0 s

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

Parameter: Function monitoring

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

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

Voltage Controller Only Grid Coupling Transformer

Parameter: Power-flow supervision

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

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

Line Compensation for the Two-Winding Transformer

Parameter: Line drop compensation

- Default setting (_:14011:125) Line drop compensation = off

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

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

Parameter: Target voltage rising

- Default setting (_:14011:126) Target voltage rising = 0.0 %

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

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

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

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

Parameter: Max load current

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

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

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

Parameter: R line

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

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

Parameter: X line

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

With the X line parameter, you set the reactance for the line to be protected. The parameter R line and X line is necessary in order to determine the voltage drop by the line. Entering the parameter for the procedure Line drop compensation = LDC-XandR. If the primary values are known and you would like to set the secondary values, use the following formula for the calculation:

$$X_{sec} = \frac{Ratio_I}{Ratio_V} \cdot X_{prim}$$

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

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

Therefore, the result for X_{sec} is:

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

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

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

Parameter: Line drop compensation

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- Default setting (_:124) Line drop compensation = off

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

Parameter: Target voltage rising w1

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

Parameter: Target voltage rising w2

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

Parameter: Max load current

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

Consider the following parameter for Line drop compensation = LDC-XandR

Parameter: R line w1

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

Parameter: R line w2

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

Parameter: X line w1

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

Parameter: X line w2

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

Limiting Values for the Two-Winding Transformer

Parameter: Lower tap-position limit

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

Parameter: Higher tap-position limit

- Default setting (_:14011:103) Higher tap-position limit = 15

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

Parameter: Vmin limiting

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

Parameter: Vmin threshold

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

Parameter: Vmin time delay

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

Parameter: Vmax limiting

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

Parameter: Vmax threshold

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

Parameter: Vmax time delay

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

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

Limiting Values for Three-Winding Transformers and Grid Coupling Transformers

Parameter: Vmin threshold w1

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

Parameter: Vmin threshold w2

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

Parameter: Vmax threshold w1

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

Parameter: Vmax threshold w2

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

Blockings for the Two-Winding Transformers

Parameter: Blocking behavior

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

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

Parameter: V< Blocking

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

Parameter: V< Threshold

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

Parameter: V< Time delay

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

Parameter: I> Blocking

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

Parameter: I> Threshold

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

Parameter: I> Time delay

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

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

Parameter: I< Blocking

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

Parameter: I< Threshold

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

Parameter: I< Time delay

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

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

Blockings for Three-Winding Transformers and Grid Coupling Transformers

Parameter: V< Threshold w1

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

Parameter: V< Threshold w2

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

7.9.5 Settings

Two-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Ref. for %-values				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15
General				
_:14011:1	90V V.contr.2w:Mode		• off • on • test	on
_:14011:101	90V V.contr.2w:Operating mode		• Manual • Auto	Manual
Control				
_:14011:107	90V V.contr.2w:Check switching authority		• no • yes	yes
_:14011:109	90V V.contr.2w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:14011:110	90V V.contr.2w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:14011:111	90V V.contr.2w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:14011:156	90V V.contr.2w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:14011:112	90V V.contr.2w:Target voltage 1		10.000 V to 340.000 V	110.000 V
_:14011:157	90V V.contr.2w:Target voltage 2		10.000 V to 340.000 V	110.000 V
_:14011:158	90V V.contr.2w:Target voltage 3		10.000 V to 340.000 V	110.000 V
_:14011:159	90V V.contr.2w:Target voltage 4		10.000 V to 340.000 V	110.000 V

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

Addr.	Parameter	C	Setting Options	Default Setting
_:14011:133	90V V.contr.2w:Vmax time delay		0 s to 20 s	10 s
Blocking				
_:14011:134	90V V.contr.2w:Blocking behavior		• Auto • Auto-Manual	Auto-Manual
_:14011:135	90V V.contr.2w:V< blocking		• off • on	on
_:14011:136	90V V.contr.2w:V< threshold		10.000 V to 340.000 V	90.000 V
_:14011:137	90V V.contr.2w:V< Time delay		0 s to 20 s	0 s
_:14011:138	90V V.contr.2w:I> blocking		• off • on	on
_:14011:139	90V V.contr.2w:I> threshold		10 % to 500 %	150 %
_:14011:140	90V V.contr.2w:I> Time delay		0 s to 20 s	0 s
_:14011:141	90V V.contr.2w:I< blocking		• off • on	off
_:14011:142	90V V.contr.2w:I< Threshold		3 % to 100 %	10 %
_:14011:143	90V V.contr.2w:I< Time delay		0 s to 20 s	10 s

Three-Winding Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_:2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:103	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Winding 2				
_:2311:102	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_:2311:104	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
_:2311:105	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Tap changer				
_:13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_:13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_:13981:113	Tap changer:Motor supervision time		5 s to 100 s	10 s
_:13981:116	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap
_:13981:114	Tap changer:Lowest tap position		-64 to 64	1
_:13981:115	Tap changer:Highest tap position		-64 to 64	15

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:15601:1	90V V.contr.3w:Mode		• off • on • test	on
_:15601:101	90V V.contr.3w:Operating mode		• Manual • Auto	Manual
_:15601:157	90V V.contr.3w:Winding selection		• Winding 1 • Winding 2 • WithMaxLoad	Winding 1
Control				
_:15601:107	90V V.contr.3w:Check switching authority		• no • yes	yes
_:15601:109	90V V.contr.3w:Control model		• direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:15601:110	90V V.contr.3w:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:15601:111	90V V.contr.3w:Feedback monitoring time		0.01 s to 1800.00 s	10.00 s
Voltage Control				
_:15601:164	90V V.contr.3w:Number of target voltage		• 1 • 2 • 3 • 4	1
_:15601:112	90V V.contr.3w:Target voltage 1 w1		10.000 V to 340.000 V	110.000 V
_:15601:165	90V V.contr.3w:Target voltage 2 w1		10.000 V to 340.000 V	110.000 V
_:15601:166	90V V.contr.3w:Target voltage 3 w1		10.000 V to 340.000 V	110.000 V
_:15601:167	90V V.contr.3w:Target voltage 4 w1		10.000 V to 340.000 V	110.000 V
_:15601:146	90V V.contr.3w:Target voltage 1 w2		10.000 V to 340.000 V	110.000 V
_:15601:168	90V V.contr.3w:Target voltage 2 w2		10.000 V to 340.000 V	110.000 V
_:15601:169	90V V.contr.3w:Target voltage 3 w2		10.000 V to 340.000 V	110.000 V
_:15601:170	90V V.contr.3w:Target voltage 4 w2		10.000 V to 340.000 V	110.000 V
_:15601:113	90V V.contr.3w:Bandwidth		0.2 % to 10.0 %	1.0 %
_:15601:114	90V V.contr.3w:T1 characteristic		• Linear • Inverse	Linear
_:15601:115	90V V.contr.3w:T1 delay		5 s to 600 s	40 s
_:15601:116	90V V.contr.3w:T1 Inverse Min		5 s to 100 s	5 s
_:15601:117	90V V.contr.3w:T2 delay		0 s to 100 s	5 s
_:15601:118	90V V.contr.3w:Fast step up		• off • on	off

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Addr.	Parameter	C	Setting Options	Default Setting
_15601:119	90V V.contr.3w Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_15601:120	90V V.contr.3w Fast step up T delay		0.0 s to 10.0 s	2.0 s
_15601:121	90V V.contr.3w Fast step down		• off • on	on
_15601:122	90V V.contr.3w Fast step down limit		0.0 % to 50.0 %	6.0 %
_15601:123	90V V.contr.3w Fast step down T delay		0.0 s to 10.0 s	0.0 s
_15601:124	90V V.contr.3w Function monitoring		0 min to 120 min	15 min
_15601:162	90V V.contr.3w Power flow supervision		• off • on	on
_15601:163	90V V.contr.3w Regulate with T2 at start		• off • on	on
_15601:171	90V V.contr.3w Set point mode active		• off • on	on
Line drop comp.				
_15601:125	90V V.contr.3w Line drop compensation		• off • LDC-Z • LDC-X and R	off
_15601:126	90V V.contr.3w Target voltage rising w1		0.0 % to 20.0 %	4.0 %
_15601:147	90V V.contr.3w Target voltage rising w2		0.0 % to 20.0 %	4.0 %
_15601:127	90V V.contr.3w Max load current		0.0 % to 500.0 %	100.0 %
_15601:153	90V V.contr.3w R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_15601:154	90V V.contr.3w X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_15601:155	90V V.contr.3w R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_15601:156	90V V.contr.3w X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_15601:102	90V V.contr.3w Lower tap-position limit		-128 to 127	1
_15601:101	90V V.contr.3w Higher tap-position limit		-128 to 127	15
_15601:128	90V V.contr.3w Vmin limiting		• off • on	on
_15601:129	90V V.contr.3w Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_15601:148	90V V.contr.3w Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_15601:130	90V V.contr.3w Vmin time delay		0 s to 20 s	10 s
_15601:131	90V V.contr.3w Vmax limiting		• off • on	on

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

Grid Coupling Transformer

Addr.	Parameter	C	Setting Options	Default Setting
Winding 1				
_2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
Winding 2				
_2311:101	General:Rated current		0.20 A to 100000.00 A	1000.00 A
_2311:102	General:Rated voltage		0.20 kV to 1200.00 kV	400.00 kV
_2311:106	General:Rated apparent power		-1.00 MVA to -1.00 MVA	0.00 MVA
Tap changer				
_13981:111	Tap changer:Maximum output time		0.02 s to 1800.00 s	1.50 s
_13981:112	Tap changer:Supervision behavior		• off • warning • alarm block	alarm block
_13981:113	Tap changer:Motor supervision time		5 s to 999 s	10 s
_13981:156	Tap changer:Highest tap changer pos.		• Lowest voltage tap • Highest voltage tap	Lowest voltage tap

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

Addr.	Parameter	C	Setting Options	Default Setting
_16351:118	90V V.contr.gc:Fast step up		• off • on	off
_16351:119	90V V.contr.gc:Fast step up limit		-50.0 % to 0.0 %	-6.0 %
_16351:120	90V V.contr.gc:Fast step up T delay		0.0 s to 10.0 s	2.0 s
_16351:121	90V V.contr.gc:Fast step down		• off • on	on
_16351:122	90V V.contr.gc:Fast step down limit		0.0 % to 50.0 %	6.0 %
_16351:123	90V V.contr.gc:Fast step down T delay		0.0 s to 10.0 s	0.0 s
_16351:124	90V V.contr.gc:Function monitoring		0 min to 120 min	15 min
_16351:162	90V V.contr.gc:Power-flow supervision		• off • on	on
_16351:163	90V V.contr.gc:Regulate with T2 at start		• off • on	on
_16351:171	90V V.contr.gc:Set point mode active		• off • on	on
Line drop comp.				
_16351:125	90V V.contr.gc:Line drop compensation		• off • LDC-Z • LDC-X and R	off
_16351:126	90V V.contr.gc:Target voltage rising w1		0.0 % to 20.0 %	4.0 %
_16351:147	90V V.contr.gc:Target voltage rising w2		0.0 % to 20.0 %	4.0 %
_16351:127	90V V.contr.gc:Max load current		0.0 % to 500.0 %	100.0 %
_16351:153	90V V.contr.gc:R line w1		0.0 Ω to 30.0 Ω	0.0 Ω
_16351:154	90V V.contr.gc:X line w1		-30.0 Ω to 30.0 Ω	0.0 Ω
_16351:155	90V V.contr.gc:R line w2		0.0 Ω to 30.0 Ω	0.0 Ω
_16351:156	90V V.contr.gc:X line w2		-30.0 Ω to 30.0 Ω	0.0 Ω
Limiting				
_16351:102	90V V.contr.gc:Lower tap-position limit		-128 to 127	1
_16351:101	90V V.contr.gc:Higher tap-position limit		-128 to 127	15
_16351:128	90V V.contr.gc:Vmin limiting		• off • on	on
_16351:129	90V V.contr.gc:Vmin threshold w1		10.000 V to 340.000 V	105.000 V
_16351:148	90V V.contr.gc:Vmin threshold w2		10.000 V to 340.000 V	105.000 V
_16351:130	90V V.contr.gc:Vmin time delay		0 s to 20 s	10 s
_16351:131	90V V.contr.gc:Vmax limiting		• off • on	on
_16351:132	90V V.contr.gc:Vmax threshold w1		10.000 V to 340.000 V	115.000 V

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

7.9.6 Information List

Two-Winding Transformer

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

No.	Information	Data Class (Type)	Type
_13981:311	Tap changer:Position failure	SPS	O
_13981:312	Tap changer:Op.ct.	INS	O
_13981:313	Tap changer:Reset failure	SPC	C
90V V.contr. 2w			
_14011:81	90V V.contr.2w:>Block	SPS	I
_14011:85	90V V.contr.2w:>Reset min./max.	SPS	I
_14011:53	90V V.contr.2w:Health	ENS	O
_14011:54	90V V.contr.2w:Inactive	SPS	O
_14011:52	90V V.contr.2w:Behavior	ENS	O
_14011:301	90V V.contr.2w:End Higher pos. Auto	SPS	O
_14011:302	90V V.contr.2w:End Lower pos. Auto	SPS	O
_14011:326	90V V.contr.2w:Cmd. with feedback	BALANCED SCORECARD	C
_14011:329	90V V.contr.2w:Block auto	SPC	C
_14011:352	90V V.contr.2w:Operating mode	SPC	C
_14011:305	90V V.contr.2w:Bandwidth >	SPS	O
_14011:306	90V V.contr.2w:Bandwidth <	SPS	O
_14011:307	90V V.contr.2w:Fast Step Up active	SPS	O
_14011:308	90V V.contr.2w:Fast Step Down active	SPS	O
_14011:309	90V V.contr.2w:Auto Monitor	SPS	O
_14011:310	90V V.contr.2w:Vmin Limiting	SPS	O
_14011:311	90V V.contr.2w:Vmax Limiting	SPS	O
_14011:315	90V V.contr.2w:Auto Blocking	SPS	O
_14011:316	90V V.contr.2w:Manual Blocking	SPS	O
_14011:317	90V V.contr.2w:V< Blocking	SPS	O
_14011:318	90V V.contr.2w:I> Blocking	SPS	O
_14011:319	90V V.contr.2w:I< Blocking	SPS	O
_14011:320	90V V.contr.2w:V act.	MV	O
_14011:321	90V V.contr.2w:dV act.	MV	O
_14011:322	90V V.contr.2w:I load	MV	O
_14011:323	90V V.contr.2w:V max	MV	O
_14011:324	90V V.contr.2w:V min	MV	O
_14011:325	90V V.contr.2w:V target	MV	O
_14011:354	90V V.contr.2w:Target voltage 1	SPC	C
_14011:355	90V V.contr.2w:Target voltage 2	SPC	C
_14011:356	90V V.contr.2w:Target voltage 3	SPC	C
_14011:357	90V V.contr.2w:Target voltage 4	SPC	C
_14011:358	90V V.contr.2w:Set target voltage	APC	C
_14011:359	90V V.contr.2w:Block. T1	SPC	C

Three-Winding Transformer

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

No.	Information	Data Class (Type)	Type
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:300	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. SA.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Oper.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C
90V V.contr.3w			
_:15601:81	90V V.contr.3w:>Block	SPS	I
_:15601:85	90V V.contr.3w:>Reset min.max.	SPS	I
_:15601:53	90V V.contr.3w:Health	ENS	O
_:15601:54	90V V.contr.3w:Inactive	SPS	O
_:15601:52	90V V.contr.3w:Behavior	ENS	O
_:15601:301	90V V.contr.3w:End Higher pos. Auto	SPS	O
_:15601:302	90V V.contr.3w:End Lower pos. Auto	SPS	O
_:15601:332	90V V.contr.3w:Cmd. with feedback	BALANCED SCORECARD	C
_:15601:335	90V V.contr.3w:Block auto	SPC	C
_:15601:336	90V V.contr.3w:Operating mode	SPC	C
_:15601:305	90V V.contr.3w:Bandwidth >	SPS	O
_:15601:306	90V V.contr.3w:Bandwidth <	SPS	O
_:15601:307	90V V.contr.3w:Fast Step Up active	SPS	O
_:15601:308	90V V.contr.3w:Fast Step Down active	SPS	O
_:15601:309	90V V.contr.3w:Auto Monitor	SPS	O
_:15601:357	90V V.contr.3w:Power-flow reverse	SPS	O
_:15601:310	90V V.contr.3w:Vmin Limiting w1	SPS	O
_:15601:311	90V V.contr.3w:Vmin Limiting w2	SPS	O
_:15601:312	90V V.contr.3w:Vmax Limiting w1	SPS	O
_:15601:313	90V V.contr.3w:Vmax Limiting w2	SPS	O
_:15601:314	90V V.contr.3w:Auto Blocking	SPS	O
_:15601:315	90V V.contr.3w:Manual Blocking	SPS	O
_:15601:316	90V V.contr.3w:V< Blocking w1	SPS	O
_:15601:317	90V V.contr.3w:V< Blocking w2	SPS	O
_:15601:318	90V V.contr.3w:I> Blocking	SPS	O
_:15601:319	90V V.contr.3w:I<. Blocking	SPS	O
_:15601:320	90V V.contr.3w:Vact.w1	MV	O
_:15601:321	90V V.contr.3w:Vact.w2	MV	O

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

Grid Coupling Transformer

No.	Information	Data Class (Type)	Type
General			
_:2311:52	General:Behavior	ENS	O
_:2311:53	General:Health	ENS	O
Tap changer			
_:13981:500	Tap changer:>Acquisition blocking	SPS	I
_:13981:501	Tap changer:>Enable	SPS	I
_:13981:53	Tap changer:Health	ENS	O
_:13981:301	Tap changer:End higher pos.reached	SPS	O
_:13981:302	Tap changer:End lower pos.reached	SPS	O
_:13981:300	Tap changer:Position	BALANCED SCORECARD	C
_:13981:305	Tap changer:Higher command	SPS	O
_:13981:306	Tap changer:Lower command	SPS	O
_:13981:307	Tap changer:Command active	SPS	O
_:13981:309	Tap changer:Motor sup. time expired	SPS	O
_:13981:310	Tap changer:Trigger motor prot. SA.	SPS	O
_:13981:311	Tap changer:Position failure	SPS	O
_:13981:312	Tap changer:Oper.ct.	INS	O
_:13981:319	Tap changer:Reset failure	SPC	C

No.	Information	Data Class (Type)	Type
90V V.contr.gc			
_:16351:81	90V V.contr.gc:>Block	SPS	I
_:16351:85	90V V.contr.gc:>Reset min.max.	SPS	I
_:16351:53	90V V.contr.gc:Health	ENS	O
_:16351:54	90V V.contr.gc:Inactive	SPS	O
_:16351:52	90V V.contr.gc:Behavior	ENS	O
_:16351:301	90V V.contr.gc:End Higher pos. Auto	SPS	O
_:16351:302	90V V.contr.gc:End Lower pos. Auto	SPS	O
_:16351:333	90V V.contr.gc:Cmd. with feedback	BALANCED SCORECARD	C
_:16351:335	90V V.contr.gc:Block auto	SPC	C
_:16351:336	90V V.contr.gc:Operating mode	SPC	C
_:16351:305	90V V.contr.gc:Bandwidth >	SPS	O
_:16351:306	90V V.contr.gc:Bandwidth <	SPS	O
_:16351:307	90V V.contr.gc:Fast Step Up active	SPS	O
_:16351:308	90V V.contr.gc:Fast Step Down active	SPS	O
_:16351:309	90V V.contr.gc:Auto Monitor	SPS	O
_:16351:357	90V V.contr.gc:Power-flow reverse	SPS	O
_:16351:310	90V V.contr.gc:Vmin Limiting w1	SPS	O
_:16351:311	90V V.contr.gc:Vmin Limiting w2	SPS	O
_:16351:312	90V V.contr.gc:Vmax Limiting w1	SPS	O
_:16351:313	90V V.contr.gc:Vmax Limiting w2	SPS	O
_:16351:314	90V V.contr.gc:Auto Blocking	SPS	O
_:16351:315	90V V.contr.gc:Manual Blocking	SPS	O
_:16351:316	90V V.contr.gc:V< Blocking w1	SPS	O
_:16351:317	90V V.contr.gc:V< Blocking w2	SPS	O
_:16351:318	90V V.contr.gc:I> Blocking	SPS	O
_:16351:319	90V V.contr.gc:I<. Blocking	SPS	O
_:16351:320	90V V.contr.gc:Vact.w1	MV	O
_:16351:321	90V V.contr.gc:Vact.w2	MV	O
_:16351:323	90V V.contr.gc:I load w1	MV	O
_:16351:324	90V V.contr.gc:I load w2	MV	O
_:16351:325	90V V.contr.gc:Vmax 1	MV	O
_:16351:326	90V V.contr.gc:Vmax 2	MV	O
_:16351:327	90V V.contr.gc:Vmin 1	MV	O
_:16351:328	90V V.contr.gc:Vmin 2	MV	O
_:16351:329	90V V.contr.gc:V tar.w1	MV	O
_:16351:330	90V V.contr.gc:V tar.w2	MV	O
_:16351:358	90V V.contr.gc:Target voltage 1 w1	SPC	C
_:16351:359	90V V.contr.gc:Target voltage 2 w1	SPC	C
_:16351:360	90V V.contr.gc:Target voltage 3 w1	SPC	C
_:16351:361	90V V.contr.gc:Target voltage 4 w1	SPC	C
_:16351:362	90V V.contr.gc:Target voltage 1 w2	SPC	C
_:16351:363	90V V.contr.gc:Target voltage 2 w2	SPC	C
_:16351:364	90V V.contr.gc:Target voltage 3 w2	SPC	C

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

8 Supervision Functions

8.1 Overview

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

- Ensures the availability of the technology used
- Avoids malfunction and overfunction of the device
- Protects persons and primary technical devices
- Offers effective assistance during commissioning and testing

The following areas are monitored:

- Supervision the resource consumption of the application
- Supervision of the secondary system
- Supervision of device hardware
- Supervision of device firmware
- Supervision of hardware configuration
- Supervision of communication connections

When the supervision functions pick up, that will be displayed and also indicated. Error responses are defined for the device. The error responses are grouped in defect severities.

The supervision functions work selectively. When the supervision functions pick up - as far as possible - only the affected parts of the hardware and firmware are blocked. If this is not possible, the device goes out of operation into a secure state (fallback mode). In addition to safety, this warrants a high degree of availability.

8.2 Resource-Consumption Supervision

8.2.1 Load Model

SIPROTEC 5 devices are freely configurable. A load model is integrated in DIGSI 5. The load model prevents you from overloading the device with an excessively large application.

The load model shows the device utilization and the response times for device functions. If it determines that an application created is likely to overload the device, DIGSI prevents the application from being loaded into the device.

In this rare case, you must then reduce the application in order to be able to load it into the device.

The load model can be found in the DIGSI 5 project tree under Name of the device → Device information. In the operating range, select the Resource consumption setting sheet. The following figure shows an example of the view of the load model in DIGSI 5:

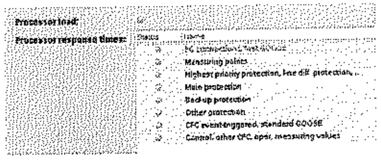


Figure 8-1 Visualization of the Load Model in DIGSI

A green total display for the processor response time indicates that the device is not overloaded by the present application. On the other hand, if you see a red exclamation mark, the planned application is overloading the device.

The list below the load display shows the individual functional areas. These areas combine functions with the same real-time requirements in groups. A green display in front of an area (see Figure 8-1) indicates that the response times of the functions grouped in this area can be maintained. A red exclamation point indicates that functions may have longer response times than are specified in the Technical data for the device. In such a case, loading of the application into the device is blocked.

The following table provides an overview of the functional areas and the most important influencing quantities on device utilization:

Functional Area	Brief Description	Change in Load
CFC event-triggered, fast	CFC charts that must be processed especially fast (for example, to invoke interlockings between protection functions)	Adding or removing CFC charts in the fast event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the fast event-triggered process area

Functional Area	Brief Description	Change in Load
Measuring points	Processing of measured values for protection, control, and measurement functions	Adding or removing • Measuring points (in the Measuring-points routing editor) • Function groups that provide measured-value preprocessing for invokable functions (for example, Line function group and Circuit-breaker function group)
• FG connections • Fast GOOSE	• Interaction between individual function groups, for example, between the Line function group and the Circuit-breaker function group • Fast GOOSE communication	Adding or removing • Protection functions and their stages • Circuit-breaker function groups • Fast GOOSE connections
Protection Communication	Signal transmission via protection communication and differential protection communication	Adding or removing • Communication modules for the protection interface (in the DIGSI 5 Hardware and Protocols editor) • Routings to the protection interface • Functions of the transformer differential protection
Transformer Differential Protection	Transformer Differential Protection	Adding or removing differential protection functions
Main protection	Protection functions with high requirements for fast operate times	Adding or removing • Functions and zones of the distance protection; functions and tripping stages of the ground-fault protection • Power-swing blocking function and tripping stages of instantaneous high-current tripping
Backup protection	Protection functions with average requirements for fast operate times	Adding or removing • Functions and stages of overcurrent protection • Synchronization function
Other protection	Protection functions with low requirements for fast operate times	Adding or removing • Overload protection functions • Functions and stages of voltage protection • All functions not listed previously
CFC event-triggered, standard GOOSE	CFC charts with a maximum processing time of 40 ms	Adding or removing CFC charts in the event-triggered process range • Create CFC chart • Delete CFC chart • Change the process range in the properties of the CFC chart Add to or remove from CFC charts in the event-triggered process area
• Control • Other continuous function chart • Operational measured values	• Control and interlocking • CFC charts in the area of control, measured-value preprocessing, and event-controlled • Operational measured values	Adding or removing • Function blocks for control and interlocking • CFC charts in the control area • Switching devices (except circuit breakers), for example, disconnector function groups • Operational measured values • CFC charts in the measured values area

If the load model displays a warning, bear in mind the following general instructions:

The areas named in the table are listed in decreasing order of real-time requirements. If a warning appears to the effect that the guaranteed response times may be exceeded in an area, you may be able to return to the permitted area by taking the following measures:

- Reduce the functional scope in the marked area (red exclamation mark)
- Reduce the functional scope in another area with higher real-time requirements

When you have reduced the application, check the display in resource consumption. If a function or stage has been switched off, it will continue to represent a load for the area. If you do not need the function or stage, delete it rather than switching it off.

Use the general Circuit-breaker function group only in the following cases:

- Interaction with a protection function group is essential.
  That is, operate indications of protection functions cause the circuit breaker assigned to the Circuit-breaker function group to be switched off.
- You want to use functions such as the automatic reclosing function or circuit-breaker failure protection in the Circuit-breaker function group.

If a circuit breaker is only to be modeled for control purposes, use the Circuit breaker [state only] function group.

8.2.2 Function Points

When you order a SIPROTEC 5 device, you are also ordering a function points account for use of additional functions.

The following figure illustrates consumption of function points in the current application with respect to the existing function-points account.

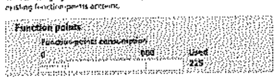


Figure 8-2 Resource Overview: Function Points Consumption

The remaining white bar shows the function points that have not yet been used up by your configuration. The number of function points available in a device depends on the device purchase order (position 28 of the product code). You can also order function points subsequently, and so increase the function points account for the device.

> **NOTE**
> Find out the function-points requirement for the desired application before ordering the device. For this you can use the device configurator.

8.2.3 CFC Resources

Task Levels of the CFC Function

A CFC chart, and thus the configured CFC function, runs in the SIPROTEC 5 device on exactly one of the 4 task levels. The individual task levels differ, on the one hand, in the priority of processing tasks and, on the other, in the cyclic or event-triggered processing of the CFC charts.

You can select between the following task levels:

Task Level	Description
Fast Event-Triggered	Use the Fast Event-Triggered task level for time-critical tasks, for example, if a signal should block a protection function within 2 ms to 3 ms. Functions on this task level are processed in an event-triggered way with the highest priority. Each change to a logical input signal is immediately processed. Processing can interrupt the execution of protection functions and functions on the Event-Triggered task level.
Event-Triggered	Use the Event-Triggered task level preferably for logic functions that need not be executed with highest priority. Each change to a logical input signal is immediately processed. Protection functions or functions on the Fast Event-Triggered task level can disrupt processing. Functions on the Event-Triggered task level are typically processed within a maximum of 5 ms in all devices. For busbar protection or line protection, the functions on the Event-Triggered task level are processed within a maximum of 10 ms.
Measurement	Use the Measurement task level for processing measured values. Functions on this task level are processed cyclically every 500 ms.
Interlocking	Use the Interlocking task level preferably for logic functions that should be executed with lower priority than functions in the Event-Triggered task level. If the available ticks of the Event-Triggered task level shown in the following figure are sufficient for the required CFC functionality, you do not need to use the Interlocking task level.

All CFC function blocks can be assigned to all the task levels. There are no device-specific function blocks. If enough ticks are available, all CFC charts can be created in the same task level. A tick is the measure of the performance requirement of CFC blocks.

The number of available ticks for each task is calculated depending on the created device configuration. This calculation is based on the previously described load model. In this process, it is recommended to create all selected functions and objects first followed by configuration of the CFC charts so that a realistic information about the remaining system capacities for CFC charts is available. Significantly exceeding the typical response time is prevented by the load model by limiting the number of CFC function blocks in the corresponding task level via the number of ticks available.

The typical response times for CFC tasks are listed in the Technical Data.

The following figure shows an example of the CFC chart capacities in DIGSI calculated by the load model. The ticks available for each task are shown here. The green bars represent the ticks used in the task levels. You reach this dialog with the following task: Device → Device information → Resource consumption.

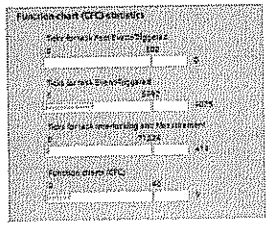


Figure 8-3 CFC Statistics

> **NOTE**
> The fast-event-triggered CFC charts have the highest priority and are processed before all other tasks. At this level, a considerably smaller number of ticks are available than at all other tasks. It is recommended to configure only very high-priority logic functions at this task and to configure the other logic functions in any other level.

> **NOTE**
> Empty CFC charts also consume system resources. Empty charts that are not required any more should be deleted.

8.3 Supervision of the Secondary System

8.3.1 Overview

The secondary circuits establish a connection to the power system from the point of view of the device. The measuring-input circuit (currents, voltages) as well as the command circuits to the circuit breakers are monitored for the correct function of the device. The connection to the station battery is ensured with the supervision of the external auxiliary voltage. The secondary system has the following supervision systems:

Measuring circuits (voltage):

- Measuring-Voltage Failure
- Voltage-Transformer Circuit Breaker
- Voltage balance
- Voltage sum
- Voltage rotating field

Measuring circuits (currents):

- Broken conductor of the current circuits
- Current balance
- Current sum
- Current rotating field

Trip circuits

External auxiliary voltage

When these supervisions pick up, corresponding warning indications are output. Some supervisions lead directly to the blocking of affected protection functions or to the marking of measuring points that have become invalid, so that affected protection functions can go into a secure state.

A detailed description of the supervision mechanisms and their error responses can be found in the Function Description and as overall overview at the end of chapter 8.

8.3.2 Measuring-Voltage Failure

8.3.2.1 Overview of Functions

The Measuring-voltage failure detection function monitors the voltage transformer secondary circuits:

- Non-connected transformers
- Pickup of the voltage transformer circuit breaker (in the event of short circuits in the secondary circuit)
- Broken conductor in one or more measuring loops

All these events cause a voltage of 0 in the voltage transformer secondary circuits which can lead to failures of the protection functions.

For the following protection functions, the response (block/not block) to a measuring voltage failure can be set within the functions:

- Directional time overcurrent protection, phases
- Overvoltage protection with negative-sequence voltage
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with positive-sequence voltage

820

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

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

8.3.2.2 Structure of the Function

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

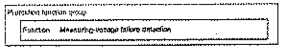


Figure 8-4 Structural Embedding of the Function

The function is broken down into 3 subfunctions (see Figure 8-5):

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

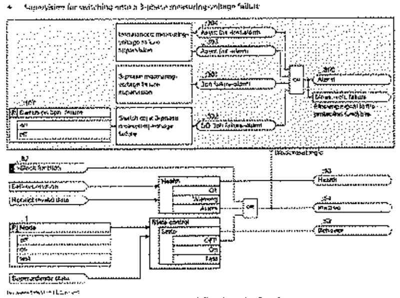


Figure 8-5 Breakdown of the Measuring Voltage Failure Detection Function

Each subfunction creates its own monitoring indication. The function summarizes these indications via the group indication Alarm.

The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

8.3.2.3 Unbalanced Measuring-Voltage Failure

Logic

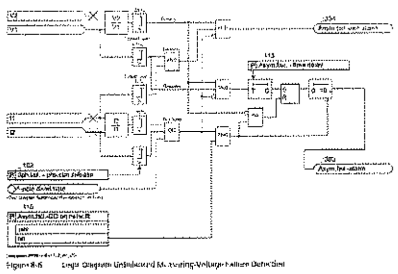


Figure 8-6 Logic Diagram Unbalanced Measuring-Voltage Failure Detection

The criterion for detection of an unbalanced measuring voltage failure is the voltage unbalance. This unbalance is determined based on the ratio between negative and positive-sequence voltage. If the threshold value is violated and the monitoring is released and not blocked, the monitoring picks up (see Figure 8-6). The indication Asym.fail. - Inst.alarm is output.

The monitoring is released as soon as a certain minimum voltage is exceeded. This prevents a spurious response in the presence of low voltage measurands or a measurand of 0 (for example, circuit breaker open). Instantaneous monitoring also requires the presence of a minimum current. This prevents a spurious instantaneous pick up of the monitoring in the presence of a weak infeed (current < 10 % of rated current) combined with a power-system incident.

If the voltage unbalance is blocked by unbalanced faults in the primary system, the supervision is blocked. The device detects an unbalanced fault based on the ratio between negative-sequence and positive-sequence currents. In the event of 1-pole automatic reclosing, the supervision is blocked.

Delay/Sealin

In the presence of a weak infeed (current < 10 % of rated current), certain protection functions require more time for detection of a system incident. For this purpose, the monitoring can be delayed using the Asym.fail. - time delay parameter.

If a system incident is detected during the time delay, the supervision drops off. This is because the function assumes that the unbalance - and consequently the pickup of the supervision - is due to the system incident. After the time delay has elapsed, it definitely assumes a measuring voltage failure. The monitoring seals in and the Asym.fail. - alarm indication is output. The dropout does not happen until the voltage unbalance has disappeared after a seal in time of 10 s. In the presence of 3-pole close in faults outside the protection zone, this seal-in time prevents the monitoring from dropping off too quickly and thus releasing the protection functions.

The sealing-in function can be deactivated using the Asym.fail. -DO on meas.flt. parameter. As soon as a system incident is detected, the monitoring drops off instantaneously.

8.3.2.4 3-Phase Measuring-Voltage Failure

Logic

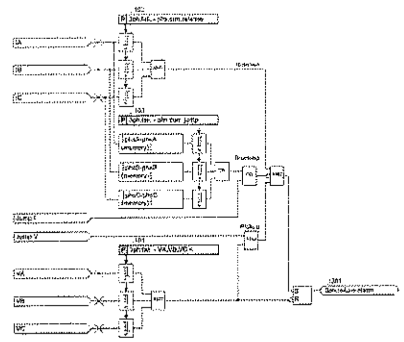


Figure 8-7 Logic Diagram 3-Phase Measuring-Voltage Failure

Balanced Fault – VA, VB, VC <

A 3-phase measuring voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages drop below the threshold value 3ph.fail. - VA,VB,VC <
- A jump of the voltage (Signal jump V)

If these criteria are fulfilled and the monitoring is released and not blocked, the 3ph.failure-alarm indication is output. When the voltage returns (even as 1 phase), the monitoring drops out.

Release by Phase Current

When all phase currents exceed the threshold value 3ph.fail. - phs.curr.release the monitoring is released.

If the device incorporates the distance-protection function, the device checks the input threshold value 3ph.fail. - phs.curr.release against the minimum current setting of the distance protection for plausibility. The threshold value 3ph.fail. - phs.curr.release must be set to less than or equal to the release current of the distance protection.

More information can be found in section Distance protection 6.17.2.1 Overview of Functions.

Blocking in the Case of a System Incident

In the case of a 3-phase system incident, supervision must be blocked. The device detects a 3-phase incident with a jump in the current. This change is detected via the internal signal Jump I or when the change in current of a phase current exceeds the threshold value 3ph.fail. - phs.curr. jump. The change in current of phase currents is formed from the difference between the present current phasor and the current phasor of the previous period. This allows to take into account a jump of the current phase.

> **NOTE**
>
> If a voltage-transformer circuit breaker is installed in the secondary circuit of the voltage transformers, its position is communicated to the device via a binary input (see chapter 8.3.4.2 Overview of Functions).

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

Logic

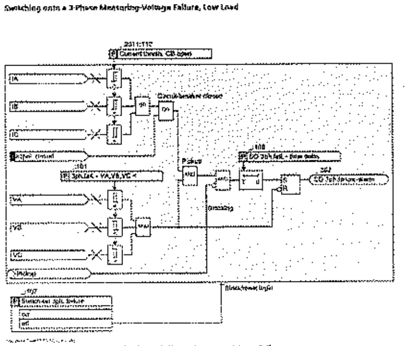


Figure 8-8 Logic Diagram Switching to 3-Phase Measuring-Voltage Failure

Switching into a 3-phase measuring voltage failure is detected if the following criteria are fulfilled simultaneously:

- All 3 phase-to-ground voltages have dropped below the threshold value 3ph.fail. - VA,VB,VC <
- The circuit breaker is detected to be in closed position. The detection takes place either via the phase currents or via the CB-pole. - closed signal, which is generated via the circuit-breaker auxiliary contacts. You can find more detailed information in chapter 5.5.4 Circuit-Breaker Condition for the Protected Object.

A voltage jump – such as in a 3-phase measuring voltage failure with closed circuit breaker (see chapter 8.3.2.4 3-Phase Measuring-Voltage Failure) – does not occur in the case of switching to a 3-phase measuring-voltage failure. If the monitoring is not blocked, the time delay SO 3ph.fail. - time delay is started. After the time has elapsed, the indication SO 3ph.failure-alarm is displayed. A dropout of the monitoring is only possible by a recovery of the voltage.

The supervision is blocked as soon as a pickup of a protection function is detected within a protection function group and the time delay of the supervision has not yet elapsed.

This subfunction also covers the situation of a low load with 3-phase measuring-voltage failure and closed circuit breaker, because the circuit breaker condition is also determined from the circuit-breaker auxiliary contacts. The subfunction for detecting a 3-phase measuring voltage failure (see chapter 8.3.2.4 3-Phase Measuring-Voltage Failure) is not released in this situation, for example, because the current flow is too low.

This subfunction can be switched on or off separately using the Switch-on 3ph. failure parameter.

8.3.2.6 Application and Setting Notes

Parameter: Asym.fail. - time delay

- Recommended setting value (_:113) Asym.fail. - time delay = 10.00 s

The Asym.fail. - time delay parameter allows you to set the time during which a system incident detected after the occurrence of the unbalance resets the monitoring. This setting is important in the case of weak infeed (current < 10 % of rated current) in order to give certain protection functions (such as distance protection) more time for detecting system incidents. As long as the time delay runs, it is assumed that the unbalance is due to a system incident.

As soon as the time has elapsed, the supervision assumes a measuring-voltage failure and seals in.

Siemens recommends using the default setting.

If you want the sealed function to operate sooner or at once, you can reduce the time.

Parameter: Asym.fail.-DO on meas.flt.

- Recommended setting value (_:115) Asym.fail.-DO on meas.flt. = no

Parameter Value	Description
no	After elapse of the time delay the supervision function seals in. Even if the system incident criterion is fulfilled, the protection functions concerned will remain blocked. This avoids an unselective tripping of the protection functions due to an absence of the measuring voltage in the case of an unbalanced system incident. This is the default setting.
yes	The seal in function is switched off. The supervision drops out immediately when a system incident is detected. With this setting, the unbalanced measuring-voltage failure is only reported, and in the event of a double failure (measuring-voltage failure and system incident in parallel), unselective tripping is preferred.

Parameter: 3ph.fail. - VA,VB,VC <

- Recommended setting value (_:101) 3ph.fail. - VA,VB,VC < = 5 V

The 3ph.fail. - VA,VB,VC < parameter allows you to set the pickup value of the monitoring.

Siemens recommends using the default setting.

If you expect major disturbances acting upon the voltage inputs, you can increase this value. Increasing the value makes the supervision more sensitive to 3-phase system incidents.

Parameter: 3ph.fail. - phs.curr.release

- Recommended setting value (_:102) 3ph.fail. - phs.curr.release = 0.1 A for I_{rated} = 1 A or 0.5 A for I_{rated} = 5 A

The 3ph.fail. - phs.curr.release parameter is used to define the phase current threshold above which the monitoring is released.

Siemens recommends using the default setting.

If the device incorporates the Distance protection function, the value must be set to less than or equal to the release current of the distance protection.

You can find more information in section Distance protection 6.17.2.1 Overview of Functions.

Parameter: 3ph.fail. - phs.curr. jump

- Recommended setting value (_:103) 3ph.fail. - phs.curr. jump = 0.1 A for I_{rated} = 1 A or 0.5 A for I_{rated} = 5 A

The 3ph.fail. - phs.curr. jump parameter is used to set the differential current between the present current phasor and the stored phasor (from the previous period). If the value is exceeded, the function detects a system incident and blocks the monitoring.

Siemens recommends using the default setting.

Parameter: SO 3ph.fail. - time delay

- Recommended setting value (_:106) SO 3ph.fail. - time delay = 3.00 s

The SO 3ph.fail. - time delay parameter allows you to set the delay of the monitoring.

Siemens recommends using the default setting.

> **NOTE**
>
> Adapt the SO 3ph.fail. - time delay parameter to the inherent time of protection functions which are intended to block the monitoring function.
>
> Note that with parameter value 0 a blocking of the monitoring function via a protection stimulation will not be possible any more.

Parameter: Operating mode

This parameter (_:4711:101) Operating mode and its settings are described in chapter Process monitor.

You can find more information starting in chapter 5.5.4.2 Overview of Functions.

Parameter: Switch-on 3ph. failure

- Recommended setting value (_:107) Switch-on 3ph. failure = on

Parameter Value	Description
on	The subfunction Switching to a 3-phase measuring-voltage failure is active. In the case of low loads, the subfunction for detection of a 3-phase measuring-voltage failure is not released, for example, because the current flow is too low. In this situation, the subfunction Switching to a 3-phase measuring-voltage failure can perform the monitoring task. Siemens recommends to switch that subfunction on.
off	With the setting off, the subfunction Switching to a 3-phase measuring-voltage failure is not active.

82.1

8.3.2.7 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Meas.v. fail.det.				
_:1	Meas.v.fail.det:Mode		• off • on • test	on
_:115	Meas.v.fail.det:Asym.fail. - I/O pri meas.flt.		• no • yes	yes
_:113	Meas.v.fail.det:Asym.fail. - time delay		0.00 s to 30.00 s	10.00 s
_:102	Meas.v.fail.det:3ph.fail. - phs.curr. release	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:103	Meas.v.fail.det:3ph. fail. - phs.curr. jump	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	Meas.v.fail.det:3ph.fail. - VA,VB,VC<		0.300 V to 340.000 V	5.000 V
_:107	Meas.v.fail.det:Switch on 3ph. failure		• off • on	on
_:106	Meas.v.fail.det:SO 3ph.fail. - time delay		0.01 s to 30.00 s	3.00 s

8.3.2.8 Information List

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

8.3.3 Signaling-Voltage Supervision

8.3.3.1 Overview of Functions

Signaling-voltage supervision is used to evaluate the validity of binary signals connected to the SIPROTEC device via binary inputs. For this purpose, one binary input is used to monitor the signaling voltage. If the

signaling voltage fails, the associated binary signals are marked as invalid and a Signaling-voltage failure indication is issued.

Several signaling voltage supervision groups can be created in one SIPROTEC device. Each of these groups monitors an adjustable area with binary inputs.

8.3.3.2 Structure of the Function

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

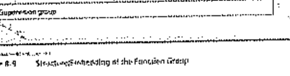
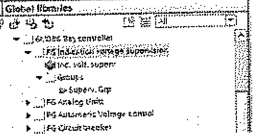


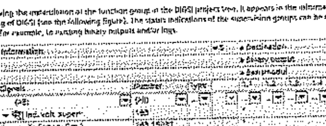
Figure 8-9 Structure/Embedding of the Function Group

8.3.3.3 Function Description

You can instantiate the Signaling-voltage supervision function group in DIGSI from the global library. It contains 1 preinstantiated Supervision group function block (see the following figure). You can instantiate a maximum of 25 supervision groups.

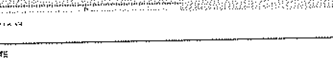


Following the instantiation of the function group in the DIGSI project tree, it appears in the information routing of DIGSI (see the following figure). The status indications of the supervision groups can be routed here, for example, to existing binary outputs and/or logs.



Set the binary input used for signaling voltage supervision within one input/output module using the setting option (see the following figure). This binary input monitors the presence of the signaling voltage. If the signaling voltage fails, this sets the quality attribute for all other binary inputs of the parameterized input/output module to invalid. The signal status of each of these binary inputs is frozen with its last valid value prior to the occurrence of the fault. The quality attribute of the binary inputs for other input/output modules are not taken into consideration by this.

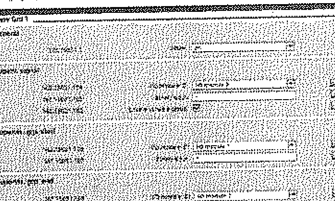
If the signaling voltage again exceeds the binary threshold, the quality attribute of the binary inputs is reset to valid.



NOTE

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

You can also combine binary inputs across modules in one Supervision group function block, and define any binary input within this group for the supervision of the signaling voltage. For this purpose, place a check mark at the parameter (_:102) Enable variable group when configuring the supervision group. This expands the parameter menu by the sections Start supervision group and End supervision group (see the following figure).



There, for example, you are able to combine 1 to n different binary inputs into one supervision group. When doing so, the binary inputs on the input-output modules assignable to a supervision group must be related logically. With 3 input/output modules, for example, this allows only consecutive binary inputs to be grouped on the modules 1+2 or 2+3, but no binary inputs on modules 1+3. The binary inputs used for supervision can be located on any input/output module within the group defined in this manner.

If you have to monitor several binary inputs that, for example, work with different signaling voltages from different sources, then you can also instantiate and configure several Supervision group function blocks within the Signaling-voltage supervision function group accordingly.

Within different supervision groups, only those consecutive binary inputs that are not already assigned to another supervision group can be grouped. The overlapping of binary inputs in different supervision groups is not permitted.

Example: There are 4 input/output modules. Binary inputs of input/output module 1+2 are already combined in supervision group 1. The 2 last binary inputs on module 2 are not included in the grouping. Thus, only these 2 binary inputs not used in the supervision group 1 of the input/output module 2 as well as, where applicable, further consecutive binary inputs of input/output modules 3+4 can be combined in supervision group 2.

Error parameters are displayed to you by inconsistency indications in DIGSI.

8.3.3.4 Application and Setting Notes

Parameter (General): Mode

- Default setting (_:1) Mode = on

With the Mode parameter, you specify whether you want to activate, deactivate, or test the supervision of the signaling voltage for the appropriate group. If you put the group into test mode, the Sig. volt. disturbed indication is given a test flag. If the supervision input drops out in test mode, the assigned inputs retain their status without their quality attribute being set to invalid.

Parameter (Supervision Signal): I/O module ID

- Default setting (_:104) I/O module ID = I/O module 1

Using the I/O module ID parameter, you specify the I/O module for which you want to activate signaling-voltage supervision. Counting of the I/O modules starts in increasing order with the binary inputs of the base module. The binary inputs of the PS201 power-supply module permanently installed in the base module count as the 2nd I/O module followed by additional I/O modules (3 to n) at the expansion boards of the device.

Parameter (Supervision Signal): Binary input

- Default setting (_:105) Binary input = 1

Using the Binary input parameter, you specify the binary input responsible for the supervision of the signaling voltage for the parameterized I/O module. The quality attribute of all other binary inputs for this module are set to valid or invalid depending on the presence of the signaling voltage at the parameterized binary input.

Parameter (Supervision Signal): Enable variable group

- Default setting (_:102) Enable variable group = unchecked

You can activate the parameter Enable variable group by placing the check mark. If you have not set the check mark (default setting), only these 2 parameters are available for the configuration of the supervision signal. If you have set the check mark, the parameter menu is expanded by the areas Start supervision group and End supervision group. You can then use this to carry out the grouping of binary inputs for supervision groups explained in the function description.

Parameter (Start Supervision Group): I/O module ID

- Default setting (_:106) I/O module ID = I/O module 1

Parameter I/O module ID is used to define the first I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the lowest counter number that you can use for carrying out a grouping.

Parameter (Start Supervision Group): Binary input

- Default setting (_:107) Binary input = 1

Parameter Binary input is used to define the lowest binary input for the first I/O module (see (_:106) I/O module ID) that you want to assign to a supervision group.

Parameter (End Supervision Group): I/O module ID

- Default setting (_:108) I/O module ID = I/O module 1

Parameter I/O module ID is used to define the last I/O module that you want to assign to a supervision group. As the counting of the I/O module starts in ascending order with the binary inputs of the base module, this is the module with the highest counter number that you can use for carrying out a grouping.

Parameter (End Supervision Group): Binary input

- Default setting (_:109) Binary input = 1

Parameter Binary input is used to define the highest binary input for the last I/O module (see (_:108) I/O module ID) that you want to assign to a supervision group.

8.3.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Superv.Grp.#:Mode		• off • on • test	on
Superv. signal				
_:104	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:105	Superv.Grp.#:Binary input		1 to 256	1
_:102	Superv.Grp.#:Enable variable group		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Superv.grp. start				
_:106	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:107	Superv.Grp.#:Binary input		1 to 256	1
Superv.grp. end				
_:108	Superv.Grp.#:I/O module ID		• I/O module 1 • I/O module 2 • I/O module 3 • I/O module 4 • I/O module 5 • I/O module 6 • I/O module 7 • I/O module 8 • I/O module 9 • I/O module 10 • I/O module 11 • I/O module 12 • I/O module 13 • I/O module 14 • I/O module 15	I/O module 1
_:109	Superv.Grp.#:Binary input		1 to 256	1

8.3.3.6 Information List

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

8.3.4 Voltage-Transformer Circuit Breaker

8.3.4.1 Overview of Functions

The Voltage-transformer circuit breaker function detects the tripping of the voltage-transformer circuit breaker due to short circuits in the voltage-transformer secondary circuits.

The Voltage-transformer circuit breaker function works independently of Measuring-voltage failure detection and should be used – if possible – in parallel to it.

The tripping of the voltage-transformer circuit breaker has an impact on the quality of the recorded measured-value data (see chapter 3.5 Processing Quality Attributes).

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

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

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

- Directional time-overcurrent protection, phases
- Overvoltage protection with negative-sequence voltage
- Overvoltage protection with zero-sequence voltage/residual voltage
- Undervoltage protection with 3-phase voltage
- Undervoltage protection with positive-sequence voltage

8.3.4.2 Structure of the Function

The Figure 8-10 shows the position of the function in the device. Every voltage measuring point contains the Voltage-transformer circuit breaker function.

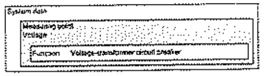


Figure 8-10 Structural embedding of the Function

8.3.4.3 Function Description

The tripping of the voltage-transformer circuit breaker is reported via the binary input signal >Open. With an active input signal the information about the measuring-voltage failure is relayed to the affected functions (see 8.3.4.1 Overview of Functions). The response to the detection of a measuring-voltage failure is explained in the specific protection-function descriptions.

Response Time of the Voltage-Transformer Circuit Breaker

The response time of the voltage-transformer circuit breaker can be slower than the pickup time of the distance protection. This bears the risk of an overfunction. The response time is communicated to the device with the Response time parameter. For a timely detection of the tripping of the voltage-transformer circuit breaker, the pickup of the distance protection is delayed by that response time.

8.3.4.4 Application and Setting Notes

The function is always active and need not be switched on.

Input Signal: >Open

- Input signal: (_:500) >Open

The input signal >Open must be connected to the tripping of the voltage-transformer circuit breaker. As a rule, this occurs via the routing to a binary input.

Parameter: Response time of the voltage-transformer circuit breaker

- Recommended setting value (_:101) Response time = 0 ms

When the voltage-transformer circuit breaker drops out, the device must block the distance protection immediately to prevent an unwanted tripping of the distance protection due to the absence of the measuring voltage while the load current is flowing.

The blocking must be faster than the 1st stage of the distance protection. This requires an extremely short response time of the miniature circuit breaker (≤ 3 ms at 50 Hz; ≤ 3 ms at 60 Hz rated frequency). If the circuit-breaker auxiliary contact does not fulfill this requirement, you have to set the response time accordingly.

8.3.4.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
VT miniatureCB				
_:101	VT miniatureCB:Response time		0.00 s to 0.03 s	0.00 s

8.3.4.6 Information List

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

8.3.5 Voltage-Balance Supervision

8.3.5.1 Overview of Functions

In healthy system operation, a certain balance between voltages can be assumed.

The Voltage-balance supervision function detects the following errors:

- Unbalance of phase-to-phase voltages in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The voltage measurement is based on the RMS values of the fundamental component.

8.3.5.2 Structure of the Function

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

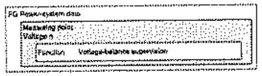


Figure 8-11 Structure/Embedding of the Function

8.3.5.3 Function Description

The voltage balance is checked by a magnitude supervision function. This function relates the smallest phase-to-phase voltage to the largest phase-to-phase voltage. Unbalance is detected if

|Vmin| / |Vmax| < Threshold min/max, as long as Vmax > Release threshold.

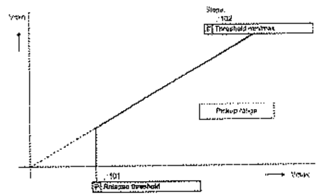


Figure 8-12 Characteristic of the Voltage-Balance Supervision

Logic

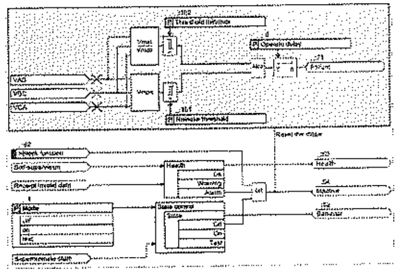


Figure 8-13 Logic Diagram of the Voltage-Balance Supervision

The Threshold min/max parameter is the criterion by which a phase-to-phase voltage unbalance is measured. The device calculates the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage.

Enter the lower limit of the maximum phase-to-phase voltage (V_{max}) with the parameter Release threshold. This specifies the lower limit of the operating range of this function.

Operate delay

If it falls below the balance factor Threshold min/max and at the same time the maximum phase-to-phase voltage exceeds the Release threshold, the Operate delay begins. If both conditions persist during this time, the indication Failure is generated.

8.3.5.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value (_:102) Threshold min/max = 0.75

The Threshold min/max parameter is used to set the ratio between the minimum (V_{min}) and the maximum (V_{max}) phase-to-phase voltage. Siemens recommends using the default setting.

Parameter: Release threshold

- Recommended setting value (_:101) Release threshold = 50 V

With the Release threshold parameter you set the lower limit of the maximum phase-to-phase voltage (V_{max}). Siemens recommends using the default setting.

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

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

8.3.5.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. V				
_:1	Supv. balan. V:Mode		• off • on • test	off
_:101	Supv. balan. V:Release threshold		0.300 V to 170.000 V	50.000 V
_:102	Supv. balan. V:Threshold min/max		0.58 to 0.95	0.75
_:6	Supv. balan. V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.5.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. V			
_:82	Supv. balan. V:>Block function	SPS	I
_:54	Supv. balan. V:Inactive	SPS	O
_:52	Supv. balan. V:Behavior	ENS	O
_:53	Supv. balan. V:Health	ENS	O
_:71	Supv. balan. V:Failure	SPS	O

8.3.6 Voltage-Sum Supervision

8.3.6.1 Overview of Functions

In healthy system operation, the sum of all voltages at one measuring point must be approximately 0. The Voltage-sum supervision monitors the sum of all voltages of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit. For summation of the voltages, the 3 phase-to-ground voltages and the residual voltage (open-delta voltage of an open circuited delta winding) are required.

The voltage measurement is based on the RMS values of the fundamental component.

NOTE

For the Voltage-sum supervision, the externally generated residual voltage must be connected to the 4th voltage measuring input.

For the Voltage-sum supervision to work correctly, the Matching ratio Vph / VN parameter must be set accordingly.

8.3.6.2 Structure of the Function

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

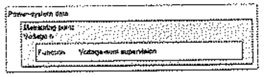


Figure 8-14 Structure/Embedding of the Function

8.3.6.3 Function Description

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

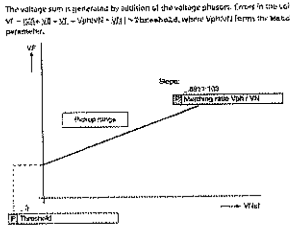


Figure 8-15 Characteristic of the Voltage-Balance Supervision

Logic

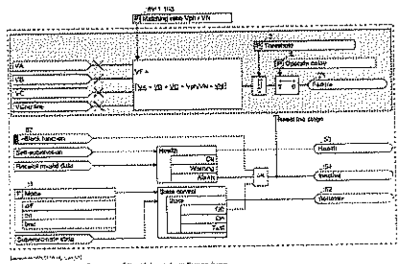


Figure 8-16 Logic Diagram of the Voltage-Sum Supervision

The device measures the phase-to-ground voltage and the ground voltage of the lines to be protected. The sum of the 4 voltages must be 0.

Threshold

If the calculated fault voltage (V_F) exceeds the Threshold, the parameter Operate delay triggers the indication Failure.

The device calculates the fault voltage (V_F) with the formula

VF = |VA + VB + VC + VphN · VN|, where VphN forms the Matching ratio Vph / VN parameters.

The Matching ratio Vph / VN parameter takes into account the differing transformation ratios between the residual voltage input and the phase voltage inputs.

More information in this respect can be found in chapter 6.x.x Overview of Functions.

Operate delay

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

8.3.6.4 Application and Setting Notes

Parameter: Threshold

- Recommended setting value (_:3) Threshold = 25 V

The Threshold parameter is used to set the voltage which the device uses to recognize the calculated fault voltage V_F as a failure of the voltage sums. Siemens recommends using the default setting.

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

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

8.3.6.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum V				
_:1	Supv. sum V:Mode		• off • on • test	off
_:3	Supv. sum V:Threshold		0.300 V to 170.000 V	43.300 V
_:6	Supv. sum V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.6.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum V			
_:82	Supv. sum V:>Block function	SPS	I
_:54	Supv. sum V:Inactive	SPS	O
_:52	Supv. sum V:Behavior	ENS	O
_:53	Supv. sum V:Health	ENS	O
_:71	Supv. sum V:Failure	SPS	O

8.3.7 Voltage Phase-Rotation Supervision

8.3.7.1 Overview of Functions

The Voltage phase-rotation supervision function monitors the phase sequence of the secondary-circuit voltages by monitoring the sequence of the zero crossings (with same sign) of the voltages. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the Phase sequence parameter.

8.3.7.2 Structure of the Function

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

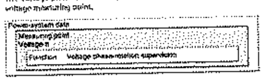

Figure 8-17 Structural embedding of the Function

8.3.7.3 Function Description

Logic

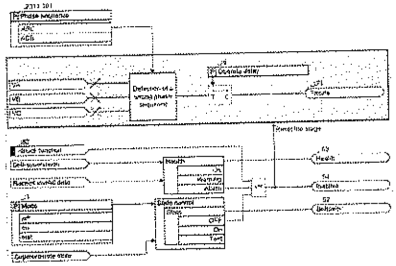

Figure 8-18 Logic Diagram for the Voltage Phase-Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.

You can find detailed information in the section Power-system data.

The phase rotation is important for protection functions which process phase, loop, and directional information. The connection of the currents to the device does not depend on the selected phase sequence.

The connection diagrams are shown in the section Appendix.

Operate delay

When the device detects an inverted phase-rotation direction for the duration of the Operate delay, the indication Failure is generated.

8.3.7.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

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

8.3.7.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph.seq. V				
_:1	Supv. ph.seq. V:Mode		• off • on • test	off
_:6	Supv. ph.seq.V:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.7.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph.seq. V			
_:82	Supv. ph.seq.V:>Block function	SPS	I
_:54	Supv. ph.seq. V:Inactive	SPS	O
_:52	Supv. ph.seq.V:Behavior	ENS	O
_:53	Supv. ph.seq.V:Health	ENS	O
_:71	Supv. ph.seq.V:Failure	SPS	O

8.3.8 Current-Balance Supervision

8.3.8.1 Overview of Functions

In healthy network operation, a certain balance between currents can be assumed.

The Current-balance supervision function detects the following errors:

- Unbalance of phase currents in the secondary circuit
- Connection errors during commissioning or short circuits and interruptions in the secondary circuit

The current measurement is based on the RMS values of the fundamental component.

8.3.8.2 Structure of the Function

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

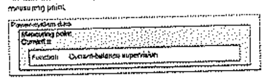

Figure 8-19 Structure/Embedding of the Function

8.3.8.3 Function Description

The current balance is checked by a magnitude monitoring function. This function relates the smallest phase current to the largest phase current. Unbalance is detected if

|Imin| / |Imax| < Threshold min/max, as long as Imax > Release threshold / IN.

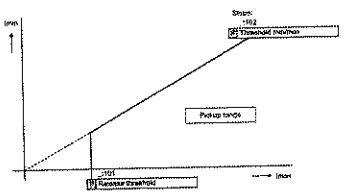

Figure 8-20 Characteristic of the Current-Balance Supervision

Logic

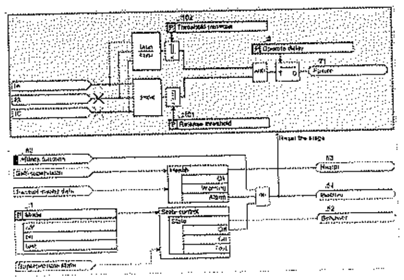

Figure 8-21 Logic Diagram of the Current-Balance Supervision

The Threshold min/max parameter is the criterion by which unbalance in the phase currents is measured. The device calculates the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Enter the lower limit of the maximum phase current (I_{max}) with the parameter Release threshold. This specifies the lower limit of the operating range of this function.

Operate delay

If it falls below the balance factor Threshold min/max and at the same time the maximum phase current exceeds the Release threshold, the tripping delay begins. If both conditions persist during this time, the indication Failure is generated.

8.3.8.4 Application and Setting Notes

Parameter: Threshold min/max

- Recommended setting value (_:102) Threshold min/max = 0.5

The Threshold min/max parameter is used to set the ratio between the minimum (I_{min}) and the maximum (I_{max}) phase current.

Parameter: Release threshold

- Recommended setting value (_:101) Release threshold = 0.5 A for I_{rated} = 1 A or 2.5 A for I_{rated} = 5 A

The Release threshold parameter is used to set the lower limit of the maximum phase current (I_{max}).

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

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

8.3.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. balan. I				
_:1	Supv. balan. I:Mode		• off • on • test	off
_:101	Supv. balan. I:Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	2.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	2.500 A
_:102	Supv. balan. I:Threshold min/max		0.10 to 0.95	0.50
_:6	Supv. balan. I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.8.6 Information List

No.	Information	Data Class (Type)	Type
Supv. balan. I			
_:82	Supv. balan. I:>Block function	SPS	I
_:54	Supv. balan. I:Inactive	SPS	O
_:52	Supv. balan. I:Behavior	ENS	O
_:53	Supv. balan. I:Health	ENS	O
_:71	Supv. balan. I:Failure	SPS	O

8.3.9 Current-Sum Supervision

8.3.9.1 Overview of Functions

In healthy system operation, the sum of all currents at one measuring point must be approximately 0. The Current-sum supervision monitors the sum of all currents of one measuring point in the secondary circuit. It detects connection errors during commissioning or short circuits and interruptions in the secondary circuit.

For summation of the currents, the device requires the phase currents and the ground current of the current transformer neutral point or of a separate ground-current transformer at this measuring point. The following connection variants are available:

- Current-transformer connections connected to 3 current transformers and the neutral point (see Figure A-10 in the Attachment)
- Ground current detected with 3 separate ground current transformers (see Figure A-12 in the Attachment)
- 3 current transformers and one summation current transformer connected (see Figure A-11 in the Attachment)
- 2 current transformers and one summation current transformer connected (see A.10 Connection Examples for Current Transformers in the Attachment)

NOTE

For current-sum supervision, the ground current of the line to be protected must be connected to the 4th current measurement input (I_4).

8.3.9.2 Structure of the Function

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

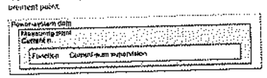

Figure 8-22 Structural Embedding of the Function

8.3.9.3 Function Description

The current sum is generated by addition of the current phasors. Errors in the current circuits are detected if

$I_F = |I_A + I_B + I_C + k_I \cdot I_N|$ > Threshold + Slope factor · Σ | I |

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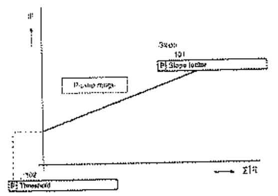

Figure 8-23 Characteristic of the Current-Sum Supervision

Logic

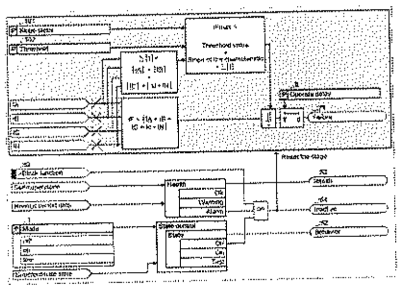

Figure 8-24 Logic Diagram of the Current-Sum Supervision

Slope of the Characteristic Curve

The Slope factor · Σ|I| part takes into account permissible current-proportional transformation errors of the transformer, which can occur in the case of high short-circuit currents.

The Slope factor and Threshold parameters are used to set the fault current limit ($I_{F,lim}$) for the current-sum supervision. The device calculates this fault current limit with the formula:

$I_{F,lim}$ = Threshold + Slope factor · Σ|I|

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

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

with k_I taking into account a possible difference from the transformation ratio of a separated ground current transformer (I_N), for example, cable-type current transformer.

- Transformation ratio of residual current converter: $Ratio_N$
- Transformation ratio of phase current converter: $Ratio_{ph}$

$$k_I = \frac{Ratio_N}{Ratio_{ph}}$$

Threshold

The Threshold parameter is the lower limit of the operating range of the Current-sum supervision function.

Operate delay

When the calculated fault current (I_F) exceeds the calculated fault current limit ($I_{F,lim}$), the Operate delay starts. If the threshold value violation persists for this time, the Failure indication is generated.

8.3.9.4 Application and Setting Notes

Parameter: Slope factor

- Recommended setting value (_:101) Slope factor = 0.1

The Slope factor parameter is used to set the ratio between the maximum (I_{max}) and the minimum (I_{min}) phase current. This function calculates the RMS values.

Parameter: Threshold

- Recommended setting value (_:102) Threshold = 0.1 A for I_{rated} = 1 A or 0.5 A for I_{rated} = 5 A

The Threshold parameter is used to set the maximum phase current (I_{max}).

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

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

8.3.9.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. sum I				
_:1	Supv. sum I:Mode		• off • on • test	off
_:102	Supv. sum I:Threshold	1 A @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:101	Supv. sum I:Slope factor		0.00 to 0.95	0.10
_:6	Supv. sum I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.9.6 Information List

No.	Information	Data Class (Type)	Type
Supv. sum I			
_:82	Supv. sum I:>Block function	SPS	I
_:54	Supv. sum I:Inactive	SPS	O
_:52	Supv. sum I:Behavior	ENS	O
_:53	Supv. sum I:Health	ENS	O
_:71	Supv. sum I:Failure	SPS	O

8.3.10 Current Phase-Rotation Supervision

8.3.10.1 Overview of Functions

The Current phase-rotation supervision function monitors the phase sequence of the secondary-circuit currents by monitoring the sequence of the zero crossings (with same sign) of the currents. This enables the device to detect connections that were inverted during commissioning. The criterion for the check is the setting of the Phase sequence parameter.

The current measurement is based on the RMS values of the fundamental component.

8.3.10.2 Structure of the Function

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

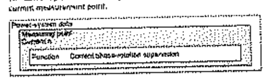

Figure 8-25 Structure/Embedding of the Function

8.3.10.3 Function Description

Logic

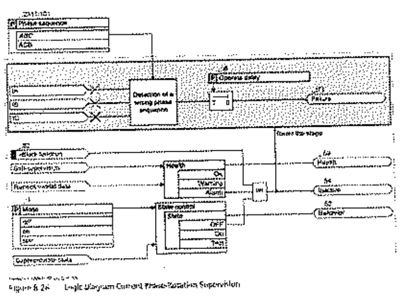

Figure 8-26 Logic Diagram Current Phase-Rotation Supervision

The device compares the measured phase sequence with the set phase-rotation direction.

You can find detailed information in the section Power-system data.

The phase-rotation is important for protection functions which process phase, loop, and directional information. The connection of the currents to the device does not depend on the selected phase sequence.

The connection diagrams are shown in the section Appendix.

Operate delay

When the device detects an inverted phase sequence for the duration of the Operate delay the indication Failure is generated.

8.3.10.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value (_:6) Operate delay = 5.00 s

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

8.3.10.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv. ph. seq. I				
_:1	Supv. ph.seq.I:Mode		• off • on • test	off
_:6	Supv. ph.seq.I:Delay supervision alarm		0.00 s to 100.00 s	5.00 s

8.3.10.6 Information List

No.	Information	Data Class (Type)	Type
Supv. ph. seq. I			
_:82	Supv. ph.seq.I:>Block function	SPS	I
_:54	Supv. ph.seq.I:Inactive	SPS	O
_:52	Supv. ph.seq.I:Behavior	ENS	O
_:53	Supv. ph.seq.I:Health	ENS	O
_:71	Supv. ph.seq.I:Failure	SPS	O

8.3.11 Trip-Circuit Supervision

8.3.11.1 Overview of Functions

The Trip-circuit supervision function recognizes disruptions in the trip circuit. When 2 binary inputs are used, the function recognizes all disruptions in the trip circuit. If only 1 binary input is available, it will not recognize disruptions at the circuit breaker.

The control voltage for the circuit breaker must be greater than the sum of the minimum voltage drops at the binary inputs V_{CTR} > 2 V_{BImin}. At least 19 V are required for each binary input. This makes the supervision usable only with a system-side control voltage of > 38 V.

8.3.11.2 Structure of the Function

The trip-circuit supervision is integrated into the Circuit-breaker function group. Depending on the number of available binary inputs, it works with 1 or 2 binary inputs.

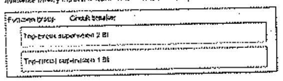

Figure 8-27 Structure/Embedding of the Function

8.3.11.3 Trip-Circuit Supervision with 2 Binary Inputs

In order to recognize disruptions in the trip circuit for each switch position, you need 2 binary inputs. One input is connected parallel to the respective command relay of the protection, the other parallel to the circuit-breaker auxiliary contact.

The following figure shows the principle of the trip-circuit supervision with 2 binary inputs.

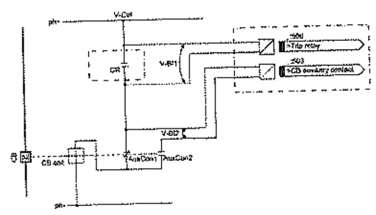

Figure 8-28 Principle of Trip-Circuit Supervision with 2 Binary Inputs

CR	Command relay
CB	Circuit breaker
CB coil	Circuit breaker coil
AuxCon1	Circuit-breaker auxiliary contact (NC)
AuxCon2	Circuit breaker auxiliary contact (NO)
V-Ctr	Control voltage (tripping voltage)
V-BI1	Input voltage for binary input 1
V-BI2	Input voltage for binary input 2

Supervision with 2 binary inputs detects disruptions in the trip circuit and the outage of the control voltage. It also monitors the reaction of the circuit breaker by way of the position of the circuit-breaker auxiliary contacts.

Depending on the switch position of the command relay and circuit breaker, the binary inputs are either activated (H) or not (L). If both binary inputs are not activated, there is a fault. The fault may be a interruption or a short circuit in the trip circuit, an outage of the battery voltage or a fault in the mechanics of the circuit breaker. With intact trip circuits, this state will occur only briefly while the command relay is closed and the circuit breaker has not yet been opened.

No.	Command Relay (CR)	CB	AuxCon1	AuxCon2	BI 1	BI 2	Dynamic State	Static State
1	Open	ON	Closed	Open	H	L	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	H	CR successfully activated the circuit breaker	

With the Alarm delay parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

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If the binary input signals >Trip relay or >CB auxiliary contact are not routed on the binary inputs of the device, then the Input sig. not routed indication is generated and the Trip-circuit supervision function is not in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 2 binary inputs.

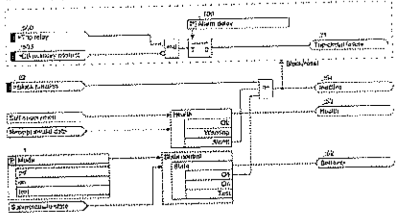


Figure 8-29 Logic Diagram of Trip-Circuit Supervision with 2 Binary Inputs

8.3.11.4 Trip-Circuit Supervision with 1 Binary Input

When using 1 binary input, you will not identify any disruptions on the circuit breaker. The binary input is connected in parallel with the respective command relay of the protection device. The circuit-breaker auxiliary contact is bridged with a high-resistance equivalent resistance R.

The following figure shows the principle of the trip-circuit supervision with 1 binary input.

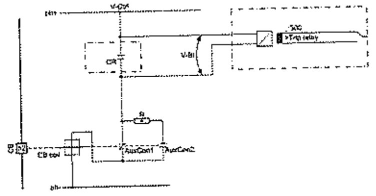


Figure 8-30 Principle of Trip-Circuit Supervision with 1 Binary Input

CR	Command relay
CB	Circuit breaker
CB coil	Circuit-breaker coil
AuxCon1	Circuit-breaker auxiliary contact (NC)
AuxCon2	Circuit-breaker auxiliary contact (NO)
V-Ctrl	Control voltage (trip voltage)
V-BI	Input voltage for binary input
R	Equivalent resistance

The supervision with 1 binary input identifies disruptions in the trip circuit and the failure of the control voltage.

In normal operation, the binary input is activated with the command relay open and the trip-circuit intact (H). The supervision circuit is closed with the equivalent resistance R or with the auxiliary contact AuxCon1 of the closed circuit breaker. The binary input is not activated while the command relay is closed (L). If the binary input is not activated for a prolonged time, there is a disruption in the trip circuit or the control voltage has failed.

No.	Command Relay	CB	AuxCon1	AuxCon2	BI	Dynamic State	Static State
1	Open	ON	Closed	Open	H	Normal operation with closed circuit breaker	
2	Open	OFF	Open	Closed	H	Normal operation with open circuit breaker	
3	Closed	ON	Closed	Open	L	Transmission or fault	Fault
4	Closed	OFF	Open	Closed	L	CR successfully activated the circuit breaker	

Use the parameter Blk. by trip/open cmd from to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

- The Trip/open cmd. of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.

As long as the trip-circuit supervision function is blocked, the closed contact of the command relay does not cause a failure indication.

If the command contacts of other devices work in parallel on the trip circuit, the failure indication must be delayed. With the Alarm delay parameter, you can set the time delay. After fixing the fault in the trip circuit, the failure indication will automatically expire after the same time.

If the binary input signal >Trip relay is not routed to a binary input of the device (information routing in DIGSI 5), then the Input sig. not routed indication is generated and Trip-circuit supervision is no longer in effect.

The following figure shows the logic diagram of the trip-circuit supervision with 1 binary input.

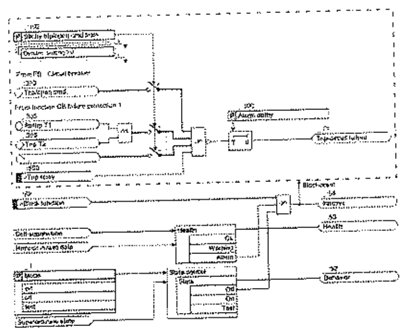


Figure 8-31 Logic Diagram of Trip-Circuit Supervision with 1 Binary Input

Equivalent Resistance R

The equivalent resistance R must be dimensioned such that the circuit-breaker coil is no longer activated when the circuit breaker is open. Simultaneously, the binary input must still be activated when the command relay is open.

In order to ensure the minimum voltage for activating the binary input, R_{max} results as:

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

So that the circuit-breaker coil does not remain activated, R_{min} results in:

$$R_{min} = R_{CBC} \cdot \left(\frac{V_{Ctrl} - V_{CBC\,(Low)\,max}}{V_{CBC\,(Low)}}\right)$$

You can calculate the optimal value for the equivalent resistance R from the 2 values R_{min} and R_{max}:

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

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

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

8.3.11.5 Application and Setting Notes

Parameter: Alarm delay

- Recommended setting value (_:100) Alarm delay = 2 s (Trip-circuit supervision with 2 binary inputs)
- Recommended setting value (_:100) Alarm delay = 300 s (Trip-circuit supervision with 1 binary input)

With the parameter Alarm delay, you can set the time for the delayed output of the indication Trip-circuit failure.

For Trip-circuit supervision with 2 binary inputs, you set the Alarm delay parameter so that the short-term transient states do not cause the function to activate.

For the Trip-circuit supervision with 1 binary input, you set the Alarm delay so that the longest duration of a trip command is bridged without fail. This ensures that the indication is emitted only if the trip circuit is actually interrupted.

Parameter: Blk.by trip/open cmd from

- Possible settings, application-dependent

The parameter works only with the trip-circuit supervision with 1 binary input.

Use the parameter Blk. by trip/open cmd from to set the conditions under which the trip-circuit supervision is blocked. The following conditions can cause a blocking of the trip-circuit supervision function:

- The Trip/open cmd. of the circuit breaker is activated.
- One of the trip commands of the circuit-breaker failure protection is activated.
- One of the trip commands of the circuit-breaker reignition protection is activated.

The circuit-breaker failure protection is set to protect a different trip circuit than the local circuit breaker. Using the configuration options of the Blk. by trip/open cmd from parameter, multiple trip-circuit supervision functions can be operated in parallel. For instance, a trip-circuit supervision function dedicated to a local circuit breaker can also be operated parallel to a higher-level circuit breaker upon which the circuit-breaker failure protection acts.

8.3.11.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
74TC sup.1BI #				
_:1	74TC sup.1BI #:Mode		• off • on • test	on
_:100	74TC sup.1BI #:Alarm delay		1.00 s to 600.00 s	300.00 s
_:102	74TC sup.1BI #:Blk.by trip/open cmd from		Setting options depend on configuration	
74TC sup.2BI #				
_:1	74TC sup.2BI #:Mode		• off • on • test	on
_:100	74TC sup.2BI #:Alarm delay		1.00 s to 30.00 s	2.00 s

8.3.11.7 Information List

No.	Information	Data Class (Type)	Type
74TC sup.1BI #			
_:82	74TC sup.1BI #:>Block function	SPS	I
_:500	74TC sup.1BI #:>Trip relay	SPS	I
_:54	74TC sup.1BI #:Inactive	SPS	O
_:52	74TC sup.1BI #:Behavior	ENS	O
_:53	74TC sup.1BI #:Health	ENS	O
_:71	74TC sup.1BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.1BI #:Input sig. not routed	SPS	O
74TC sup.2BI #			
_:82	74TC sup.2BI #:>Block function	SPS	I
_:500	74TC sup.2BI #:>Trip relay	SPS	I
_:503	74TC sup.2BI #:>CB auxiliary contact	SPS	I
_:54	74TC sup.2BI #:Inactive	SPS	O
_:52	74TC sup.2BI #:Behavior	ENS	O
_:53	74TC sup.2BI #:Health	ENS	O
_:71	74TC sup.2BI #:Trip-circuit failure	SPS	O
_:301	74TC sup.2BI #:Input sig. not routed	SPS	O

8.4 Supervision of the Device Hardware

8.4.1 Overview

The correct state of the device hardware is a requirement for the correct functioning of the device. The failure or erroneous function of a hardware component leads to device malfunctions.

The following modules of the device hardware are monitored:

- Base module
- Expansion modules
- Plug-in modules on the interface locations

The fault responses result, depending on type and degree of the error, as follows.

Hardware errors where the device remains in operation.

The error is indicated. The signals/data affected by the failure are marked as invalid. In this way, the affected protection functions can switch into a secure state. Such errors are, for example:

- Communication-module failure (module x)
- Measuring transducer module failure (module x)
- USB interface
- Integrated Ethernet interface
- Real-time clock buffering block
- A/D converter (fast current sum)
- Battery voltage
- Faulty or missing compensation values (magnitude/phase)

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Memory error (RAM) in the base module
- Faulty module
- Module connection error (PCB link)
- Control circuit error binary output
- Outage of an internal auxiliary voltage

NOTE

If the error cannot be rectified after 3 unsuccessful attempts, the system automatically recognizes it as a severe device malfunction. The device goes permanently out of operation into a secure state (fallback mode).

Fatal device errors with outage of central components. The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Memory error (Flash) in the base module
- CPU/Controller/FPGA error in the base module
- 4 unsuccessful restarts in a row

You can find the detailed description, in state form, of the fault responses at the end of chapter 8. You will find corresponding corrective measures there.

Device Operating Hours

The *Device operating hours* statistical value counts the operating hours of the physical device. The starting time and the time in fallback mode are not considered.

You can neither reset nor change the statistical value.

8.4.2 Analog-Channel Supervision via Fast Current-Sum

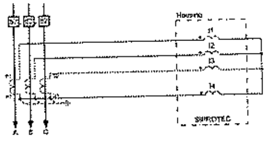
8.4.2.1 Overview of Functions

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

- Supervision of the correct functioning of the device-internal analog-digital converters, based on the sum of all currents of one measuring point in the secondary circuit.
- Detection of failures in the device-internal measuring circuits (for example, analog-digital converter)
- Blocking of protection and control functions that process the measured values from this current measuring point (for example, differential protection). This avoids an overfunction of the device.

The supervision principle is based on fast current-sum supervision with connection of the neutral-point current to the 4th current measurement input. In order to ensure that even the fast tripping stages of the protection functions can be blocked in time before a spurious pickup, the fast current measurement is based on instantaneous values.

For **Analog-digital converter supervision**, the neutral-point current of the line to be protected must be connected to the 4th current measuring input (I_4). The 4th current measuring input must be routed via the current-transformer neutral point (I_4 neutral point) (see next figure).



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

Figure 8-32 Connection to a 3-Phase Current Transformer and Measured Zero-Sequence Current (Current in Common Return Path)

NOTE

The analog channel supervision via fast current sum is only available when the 4th current input is a protection-class current transformer. In the DIGSI 5 project tree, under **Device → Measuring-point routing**, set the connection type **3-phase + IN** for the current measuring point.

8.4.2.2 Structure of the Function

The **Supervision of the device-internal analog-digital converters** function is located in the **Power system data** function group of each 3-phase current measuring point.

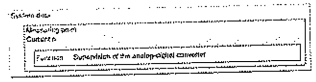


Figure 8-33 Structure/Embedding of the Function

8.4.2.3 Function Description

Errors in the current circuits are detected if

i_F = |iA + iB + iC + iN| > Threshold value + Slope of the characteristic 1 · Σ|i| and

i_F > Slope of the characteristic 2 · (Σ|i| – Base point 2)

With the current inputs iA, iB, iC, and iN, the device calculates:

- The fault current i_F = |iA + iB + iC + iN|
- The maximum current Σ|i| = |iA|+|iB|+|iC| + |iN|

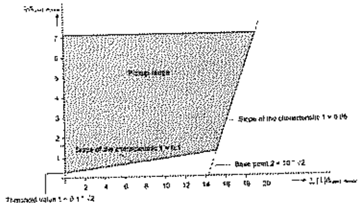


Figure 8-34 Characteristic Curve of the Supervision of the Device-Internal Analog-Digital Converters

Logic

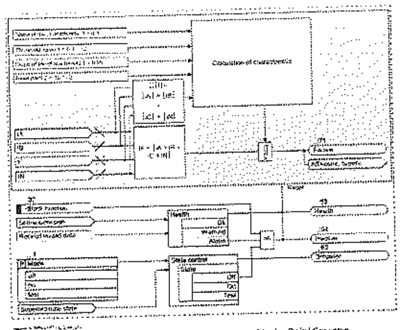


Figure 8-35 Logic Diagram of the Supervision of the Device-Internal Analog-Digital Converters

When the output signal A/D converter [illegible] is active, certain protection functions are blocked to avoid failures (see 8.4.2 Analog-Channel Supervision via Fast Current-Sum).

NOTE

The parameters are fixed in the device and cannot be changed.

It is not necessary to change the parameters depending on the application.

Threshold Value

The threshold value is the lower limit of the operating range of the **Supervision of the device-internal analog-digital converters** function.

The threshold value is fixed to 10 % of the device rated current.

Slope of the Characteristic 1

The component slope of characteristic 1 · Σ|i| takes into account permissible current-input errors, which can occur in the case of small overcurrents.

The slope of characteristic 1 is fixed to 0.1.

Slope of the Characteristic 2

The component slope of characteristic 2 takes into account permissible current-input errors, which can occur in the case of high overcurrents (high short-circuit currents).

The slope of characteristic 2 is fixed to 0.95. The base point of the slope of characteristic 2 is fixed to 10.

8.5 Supervision of Device Firmware

The device firmware determines essentially the functionality of the device.

The following supervisions ensure the stable function of the device:

- Supervision of the data and version consistency
- Supervision of the undisturbed sequential activity of the device firmware
- Supervision of the available processor performance

When you start the device, load data via the interfaces and these supervisions of the device firmware will be in effect during the continuous operation. Depending on the type and severity of error, the following error responses will result:

Firmware failures where the device remains in operation.

The error is indicated. The signals/data affected by the failure are marked as invalid. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in time synchronization (loss and errors).

Failures which can partially be corrected by a restart of the device. The device goes briefly out of operation.

Such errors are, for example:

- Device startup with faulty new parameter set. The old parameter set is still present
- Overloading of the processor
- Program sequence error

Fatal firmware error. The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Device startup with faulty new parameter set. No usable parameter set is present.
- Device startup with version error
- CFC runtime error
- 3 unsuccessful restarts in a row

You can find the detailed description, in table form, of the fault responses at the end of chapter 8. You will find corresponding corrective measures there.

8.6 Supervision of Hardware Configuration

The modular hardware concept requires adherence to some rules within the product family and the modular system. Configuration errors show that the hardware configuration saved in the device does not agree with the hardware actually detected. Impermissible components and unallowed combinations must be detected just as missing configured components are.

Depending on the type and severity of error, the following error responses will result; the identified hardware configuration errors are assigned to the defect severities as follows:

Configuration errors where the device remains in operation.

The failure is indicated. The signals/data affected by the failure are marked as invalid. In this way, the affected protection functions can go into a secure state. Such errors are, for example, errors in IE converter configuration (loss and errors).

Fatal configuration error. The device goes permanently out of operation into a secure state (fallback mode).

Such errors are, for example:

- Missing hardware module (module x)
- Incorrect hardware module (module x)
- Incorrect hardware combination
- Incorrect plug-in module (module x)

You can find the detailed description, in table form, of the error reactions at the end of chapter 8. You will find corresponding corrective measures there. You can resolve configuration errors through another synchronization with DIGSI.

8.7 Supervision of Communication Connections

SIPROTEC 5 devices offer extensive communication possibilities via fixed and optional interfaces. Beyond the hardware supervision of the communication plug-in modules the transferred data must be monitored with respect to their consistency, failure, or outage.

Supervision

With the supervision of the communication connections, every communication port is monitored separately.

- Failures are detected and indicated via the operational log. The device remains in operation.
- Each port additionally is equipped with a separate communication log, with which details of the failures (for example, error rate) are displayed.

Marking Fault Signals/Data

The signals/data affected by the failure are marked as invalid. In this way, the affected protection functions can go into a secure state. In the following, some examples are named:

- GOOSE signals can automatically be set to defined values in case of disturbed IEC 61850 communication.
- Disturbed protection interfaces set phasor values, both analog measured values and binary information to invalid (for example, for differential protection). Binary signal states can be set to defined values in cases of failures.
- Disturbed time-synchronization signals can lead to an automatic change of the source of time synchronization.

Normally, you can correct communication failures by checking the external connections or by replacing the affected communication modules. In chapter 8.8.4 Defect Severity 4, you will find the detailed description, in tabular form, of the error responses. Corresponding corrective measures can also be found there.

8.8 Error Responses and Corrective Measures

8.8.1 Overview

When device errors occur and the corresponding supervision functions pick up, this is displayed on the device and also indicated. Device errors can lead to corruption of data and signals. These data and signals are marked and tagged as invalid, so that affected functions automatically go into a secure state. If the supervision functions pick up, this will lead to defined error responses.

How Do Device Errors Make Themselves Noticeable

In case of a device error the supervision functions of the device pick up. The device responds according to the type and severity of the error. To report an error, supervision functions use outputs on the device and indications.

Run LED (green)	The external auxiliary voltage is present. The device is ready for operation.
Error LED (red)	The device is not ready for operation. The life contact is open.
Life contact	Signaling of device readiness following successful device startup.
Group-warning indication Group warning	The device remains in operation and signals an error via the permuted LED and the log.
Log of the device	Indications of causes for defects and corrective measures

Determination of Causes for Defects and Corrective Measures

To determine the cause for defect and the corresponding corrective measure, proceed step by step.

Step 1: Pickup of supervisions leads to one of the following defect severities in all cases.

- **Defect severity 1:**
  Internal or external device error that is reported. The device stays in operation.
- **Defect severity 2:**
  Severe device failure, the device restarts (reset) to correct the cause for defect.
- **Defect severity 3:**
  Severe device failure, the device goes to a safe condition (fallback mode), as the correction of defects by a restart is not possible. In fallback mode, the protection and automated functions are inactive. The device is out of operation.
- **Defect severity 4:**
  Severe device external failure, the device switches the protection and automatic functions to inactive for safety, but stays in operation. Normally, the user can correct the fault by himself.

Step 2: For every defect severity, you will find detailed tables with information about causes for defects, error responses, and corrective measures in the following chapters.

	Error Responses						
	Group-Warning Indication Group Warning	Indication in the Operational Log	Indication in the Device-Diagnosis Log	Indication of the Life Contact	All Protection and Automation Functions Are Inactive	Device Restart (Reset)	Fallback Mode
Defect severity 1	x	x	x				
Defect severity 2			x	x	During the starting time of the device	x	
Defect severity 3			x	x	x		x
Defect severity 4		x		x	x		

8.8.2 Defect Severity 1

Defect severity 1 faults allow the continued safe operation of the device. Defect severity 1 faults are indicated. The device remains in operation.

When the supervision functions pick up, corrupted data and signals are marked as invalid. In this way, the affected functions can go into a secure state. Whether functions are blocked is decided in the appropriate function itself. For more detailed information, refer to the function descriptions.

Live status contact	Remains activated
Red error LED	Is not activated

Log

For every device fault, a corresponding supervision indication is generated. The device records these indications with a real-time stamp in the operational log. In this way they are available for further analysis. If supervisions in the communication interfaces area of the device pick up, there is a separate communication log available for each port. Extended diagnostic indications and measured values are available there. The device-diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3.

Group-Warning Indication Group Warning

As delivered, all supervision indications of Defect Severity 1 are routed to the signal (_:301) Group warning. In this way, a device error can be indicated with only one indication. The majority of supervision indications are permanently connected to the Group warning indication (Group warning column = fixed). However, some supervision indications are routed flexibly to the Group warning via a CFC chart (Group warning column = CFC). If necessary, you can remove the routings via a CFC chart from the group indication.

In delivery condition, the Group warning is preset to an LED.

You can find further information on handling the logs in chapter 3.

Overview of Errors

Indication	Type	Group Warning	Explanation
General: (_:53) Health	ENS	CFC	If the Health of an individual function block, for example, a protection stage or an individual function, goes to the Warning or Alarm state, this state is processed via the associated function group up to the general group indication Health (_:53). Check via the operational log from which function or function block the error originates. You can find additional information as to why the health of the function or a function block can change in the associated function description.
(_:54) Health = Warning	SPS		
(_:55) Health = Alarm	SPS		
Device: (_:320) AuxVolt.fault	SPS	Fixed	Fault with the auxiliary power supply: Check the external power supply.
Device: (_:305) Battery fault	SPS	Fixed	Battery fault: Replace the device battery.
Device: (_:312) Compensation fault x	ENS	Fixed	Calibration error in module x: Contact the Customer Support Center. Quality: Measured values are marked with the quality attribute of questionable (measured value display with ~).
Device: (_:314) Offset error x	ENS	Fixed	Offset error on module x: If this indication persists after the device start, contact the Customer Support Center. Quality: Measured values are marked with the quality attribute of questionable (measured value display with ~).
Device: (_:306) Time failure	SPS	Fixed	Internal time failure: • Check the time settings first. • Then replace the device battery. • If the fault is not remedied, contact the Customer Support Center. Quality: The internal clock is marked with the quality attribute of Clock failure
Device: (_:319) Memory fault	SPS	Fixed	Checksum (CRC) error in monitored memory areas of the device
Device: Measuring transducer error (x)	ENS	Fixed	Hardware error on measuring transducer module in plug-in module position [illegible]. Contact the Customer Support Center.
Handling of alarms: (_:301) >Group warning	SPS	Fixed	Input signal for user-defined generation of the group warning
Time sync.: (_:303) Time sync fault	SPS	Fixed	Time synchronization error, the timing master is faulty: • Check the external time source first. • Check the external connections. • If the fault is not remedied, contact the Customer Support Center. Quality: The internal clock is marked with the quality attribute of Clock not synchronized

Indication	Type	Group Warning	Explanation
Power-system data meas. point I-3ph:Superv. sym I (_:71) Failure	SPS	CFC	Current balance failure (see chapter 8.3.8.1 Overview of Functions)
Power-system data meas. point I-3ph:Superv. PhsSeqI (_:71) Failure	SPS	CFC	Failure of current phase-rotation reversal (see chapter 8.3.10.1 Overview of Functions)
Power-system data meas. point I-3ph:Superv. Sum I (_:71) Failure	SPS	CFC	Failure of current sum (see chapter 8.3.9.1 Overview of Functions)
Power-system data meas. point I-3ph:Superv.ADC sum I (_:71) Failure	SPS	CFC	Failure of the quick current sum (see chapter 8.4.7.1 Overview of Functions) The failure indication indicates a fault in the analog-digital converter of the power input. • Check the external wiring. • If the fault is not remedied, contact the Customer Support Center. Quality: The internally managed current measured values are marked with the Invalid quality attribute. Blocking: The protection functions based on current measurement are blocked.
Power-system data meas. point V-3ph:Volt.Trans.Circ.Br. (_:500) >Open	SPS	CFC	Voltage-transformer circuit breaker is open. Blocking: Appropriate functions are either blocked definitely or you can set the blocking individually.
Power-system data meas. point V-3ph:Superv. sym V: (_:71) Failure	SPS	CFC	Voltage balance failure (see chapter 8.3.2.1 Overview of Functions)
Power-system data meas. point V-3ph:Superv. PhsSeq V: (_:71) Failure	SPS	CFC	Failure of voltage phase-rotation monitoring (see chapter 8.3.7.1 Overview of Functions)
Power-system data meas. point V-3ph:Superv. of Sum V: (_:71) Failure	SPS	CFC	Failure of voltage sum (see chapter 8.3.6.1 Overview of Functions)
2 devices prot. comm.: Protection interface #: (_:301) Open connection (_:316) Fault rate/min exceeded (_:317) Fault rate/h exceeded (_:318) Function exceeded (_:319) Runtime jump detected	SPS SPS SPS SPS SPS	CFC[1]	Protection interface connection defective: • Check the connections and the external communication infrastructure. • If the fault is not remedied, contact the Customer Support Center. Transferred Signals: Faulty or not received telegrams are detected at the receive end and discarded. They do not result in failure of the applications. Configured binary signals are reset after a time that can be set.

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

Indication	Type	Group Warning	Explanation
Superv. Meas.Volt.Fail detected: (_:300) Failure	SPS	CFC	Measuring-voltage failure detected: Check the external wiring. Blocking: Appropriate functions are either blocked definitely (for example, distance protection) or you can set the blocking individually.

8.8.3 Defect Severity 2

Faults of defect severity 2 are fatal device faults that lead to an immediate restart of the device (reset). This occurs when the device data is corrupted (for example, RAM memory). If a restart prevents restoration of data consistency, the device goes briefly out of operation, a failure is avoided.

Life contact	Is terminated during the restart
Red error LED	Is activated during the restart

> **NOTE**
>
> If the fault of defect severity 2 has not be been removed after 3 unsuccessful restarts (reset), the fault is automatically assigned to defect severity 3. The device will automatically turn to the fallback mode.

Log

For every device error with a subsequent restart (reset), only the restart can be detected in the operational log. The actual supervision indication is entered in the device-diagnosis log at the point in time of the fault detection and before the restart. These indications are recorded with a real-time stamp and are thus available for later analyses. The device-diagnosis log contains expanded fault descriptions. There you also receive recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3.

Overview of Errors

Number	Device-Diagnosis Log
826	Processor error on the base module: If the fault occurs numerous times, contact the Customer Support Center
830	FPGA hardware error on the base module: Contact the Customer Support Center.
834	Memory error (short term). Reset initiated.
3821	Program run error: If the fault occurs numerous times, contact the Customer Support Center.
826	CPU overload: If the fault occurs numerous times, contact the Customer Support Center.
Miscellaneous	Internal firmware errors: If the fault occurs numerous times, contact the Customer Support Center

8.8.4 Defect Severity 3

Faults of defect severity 3 are fatal device faults that lead to device immediately going into the fallback mode. The signal (_:2302) Device state goes to the Alarm state. The Warning state is not supported for this signal.

828

Fatal device errors are errors that cannot be resolved by a restart of the device. In this case, contact the Customer Support Center. The device goes permanently out of operation, a failure is avoided. In the fallback mode, minimal operation of the device via the on-site operation panel and DIGSI is possible. In this way, for example, you can still read out information from the device-diagnosis log.

Life contact	Is terminated in the fallback mode
Red error LED	Is activated in the fallback mode

Log

For every device error that immediately leads to entry into the fallback mode, entries from supervision messages and from the signal (_:302) Device status into the operational log are not possible. The actual supervision indication is entered in the device diagnosis log at the point in time of the fault detection, that is, before entry into the fallback mode. These indications are recorded with a real time stamp and are thus available for later analyses. The device diagnosis log contains expanded fault descriptions. There, you are offered recommendations of corresponding corrective measures for each detected device error.

You can find further information on handling the logs in chapter 3.

Overview of Errors

Number	Device-Diagnosis Log
2822	Memory error (continuous) Contact the Customer Support Center.
4727, 5016-5076	Hardware failure at module 1-12 Contact the Customer Support Center.
4729	Device bus error (repeated): • Check the module configuration and the module connections • Contact the Customer Support Center.
4733	Incorrect hardware configuration. Synchronize the hardware configuration of the device with DIGSI.
5037-5048	Wrong module 1-12 detected: Synchronize the hardware configuration of the device with DIGSI.
5071-5075	Identified wrong plug-in module on plug-in module position [illegible]: Synchronize the hardware configuration of the device with DIGSI.
	Wrong application configuration: Search for the cause in the operational log and load a valid configuration to the device.
3440, 4514	Data-structure error Contact the Customer Support Center.
956	Firmware-version error: Contact the Customer Support Center.
2018, 2025	Signature error Contact the Customer Support Center.
	CFC error: In DIGSI, check your CFC chart for the cause.
5050-5061	Binary output error in module 1 - 12: Contact the Customer Support Center.
5088, 5089	A missing display configuration was established: Synchronize the hardware configuration of the device with DIGSI.

8.8.5 Defect Severity 4 (Group Alarm)

Errors of defect severity 4 are not device failures in the classical meaning. These errors do not affect the device hardware and are not detected or reported by internal device supervision functions. The condition of the

defect severity 4 – the group alarm – is set user-specifically by the binary input signal (_:503) >Group alarm. If the binary input signal is reset, the device is no longer in the Group alarm condition and all functions return to the normal operating state.

If the group alarm is generated, the device reacts as follows:

- The group indication (_:300) Group alarm is generated and recorded in the operational log.
- The life contact is terminated.
- The red Error LED is activated.
- All protection and automation functions are blocked.
- The device remains in operation, does not carry out any restart (reset), and does not switch to the safe condition (fallback mode).
- The signals managed internally are marked with the invalid quality attribute. Signals managed internally are, for example, measured values, binary input and output signals, GOOSE and CFC signals.

In the delivery condition, every device has the CFC chart Process mode inactive, that initiates the Group alarm (see chapter 8.9 Group Indications and Predefined CFC Charts).

Life contact	Is terminated in case of Group alarm
Red error LED	Is initiated in case of Group alarm

Log

The group indication (_:300) Group alarm is recorded in the operational log. Depending on the cause of the initiation, further information can be found in the operational log.

You can find further information on handling the logs in chapter 3.

8.9 Group Indications and Predefined CFC Charts

The following group indications are available:

- (_:300) Group alarm
- (_:301) Group warning
- (_:302) Group indication

You can find the signals in the DIGSI 5 project tree under Name of the device) → Information routing. In the working range, you can find the signals under Alarm handling (see the following figure).

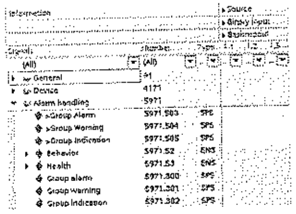


Figure 8-36 Group Monitoring Indication in the DIGSI 5 Information Routing Matrix

Group Indication Group Alarm

The indication (_:300) Group alarm is the group indication for defect-severity 4 monitoring. This monitoring has a special purpose, as it is set in a user-specific way by a binary input signal and not by internal device supervision. Nevertheless, the response of the device is serious. For example, the blocking of all protection and automation functions (see chapter 8.8.5 Defect Severity 4 (Group Alarm)).

If the binary input signal (_:503) >Group Alarm is set, the group indication (_:300) Group alarm is activated. If the binary input signal (_:503) >Group Alarm is reset, the signal (_:300) Group alarm is also reset and the device returns to the normal operating state.

In the delivery condition, every device has the CFC chart Process mode inactive that initiates the >Group alarm. This CFC chart checks whether the device is still accidentally in the simulation or commissioning mode.

You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under Name of the device → Charts.

Group Indication Group Warning

The indication (_:301) Group warning is the group indication for defect-severity 1 monitoring. Some error messages of defect severity 1 are firmly connected to the signal (_:301) Group warning, others are connected in a flexible way via a CFC chart in the device delivery condition. This allocation is described in chapter 8.8.2 Defect Severity 1.

In the delivery condition, every device has the CFC chart Group warning that initiates the Group warning. You can adapt the CFC chart as needed. You can find the CFC chart in the DIGSI 5 project tree under Name of the device → Charts.

The group-warning indication (_:301) Group warning is preset to an LED of the base module.

Group Indication

The Group indication is used only for user-specific purposes. There is no internal device supervision function that activates this indication. If the binary input signal (_:505) >Group Indication is set, the indication (_:302) Group indication is activated and recorded in the operational log. In the delivery condition, there is no further response of the device. If the binary input signal is reset, the signal (_:302) Group indication drops out. You can define via a CFC chart when the binary input signal (_:505) >Group Indication is to be set.

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

9.1 Overview of Functions

The measurands are recorded at the measuring points and forwarded to the function groups.

Within the function groups, further measurands are calculated from these measured values, which are required for the functions of this function group. This is how, for example, the electric power is calculated from the voltage and current measurands.

Measuring transducers are an exception as they already form various calculation parameters from the existing current and voltage inputs themselves.

Basic instructions for recording and editing process data can be found in the chapter 2.1 Function Embedding in the Device.

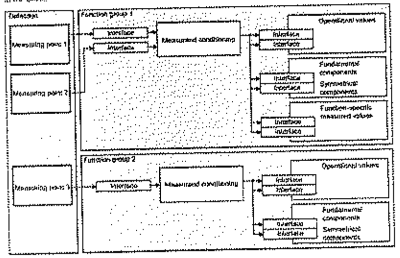


Figure 9-1 Structure of Measured Value Acquisition and Processing

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

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

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9.2 Structure of the Function

Depending on the interconnection of the function groups, these can contain different measured-value groups. A typical function group is displayed below.

3-Phase Voltage and Voltage/Current 3-Phase Function Groups

In the simplest version, the 3-phase voltage and Voltage/current 3-phase function groups offer the measured values of the 3-phase voltage and current system and contain the following measured-value groups:

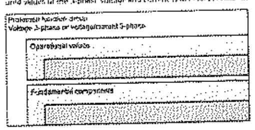


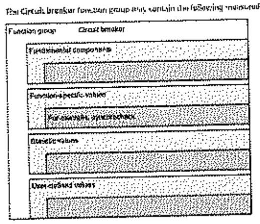
Figure 9-2 Structure of Measured Values in Function Groups

The Operational measured values and Fundamental components measured-value groups can be inserted from the DIGSI 5 library into the 3-phase voltage and Voltage/current 3-phase function groups.

Details regarding the individual measured-value groups can be found in the tables in the following chapters.

Circuit-Breaker Function Group

The Circuit breaker function group may contain the following measured values.



Inversion of Output-Related Measured and Statistical Values

The calculated, directional values in the operational measured values (power, power factor, energy and minimum, maximum, and average values based on these) are normally defined as positive in the direction of the protected object. This requires that the connection polarity for the measuring points used be correctly set

(also compare [...:8001:116] Neutr.point in dir.of ref.obj parameter of the measuring point current 3-phase). It is, however, possible, to set the "forward" direction for the protection functions and the positive direction for the powers, etc., differently, for example, so that the active power import (from the line to the busbar) is displayed positively. Then set the option P, Q sign in the affected function groups on the reversed parameter. With the parameter not reversed (default setting), the positive direction for the powers, etc., corresponds with the "forward" direction for the protection functions.

The affected values are given in detail in the Chapters 9.3 Operational Measured Values - 9.10 Statistical Values of the Primary System.

9.3 Operational Measured Values

Operational measured values are assigned to different function groups.

The values can be displayed as primary and secondary values and as percentage values.

The operational measured values are calculated according to the following definition equations:

RMS values

$$X = \sqrt{\frac{1}{T}\int_{t}^{t+T} x^2(t)dt}$$

Active power

$$P = \frac{1}{T}\int_{t}^{t+T} v(t)i(t)dt$$

Apparent power

$$S = \sqrt{3} \cdot V \cdot I$$

Reactive power

$$Q = \sum_{n} V_n \cdot I_n \cdot \sin(\varphi_n)$$

n Harmonic order

φ_n The angle difference between the voltage and current of the nth harmonic

Power factor

$$\lambda = \frac{|P|}{S}$$

Active power factor

$$\cos\varphi = \frac{P}{S}$$

Voltage/Current 3-Phase Function Group Type

The following table describes the operational measured values of the 3-phase voltage/current function group.

All protection functions have access to the values.

Table 9-1 Operational Measured Values of the Voltage/Current 3-Phase Function Group

Measured Values		Primary	Secondary	% Referenced to
I_A, I_B, I_C	Phase currents	A	A	Rated operating current of the primary values
3I0	Calculated zero-sequence current	A	A	Rated operating current of the primary values
I_N	Neutral point phase current	A	A	Rated operating current of the primary values
V_A, V_B, V_C	Phase-to-ground voltages	kV	V	Rated operating voltage of primary values/√3
V_{AB}, V_{BC}, V_{CA}	Phase-to-phase voltage	kV	V	Rated operating voltage of the primary values
V_0	Calculated zero-sequence voltage	kV	V	Rated operating voltage of primary values/√3
V_N	Measured neutral-point displacement voltage	kV	V	Rated operating voltage of primary values/√3
f	Frequency	Hz	Hz	Rated frequency
P	Active power (total power)	MW	-	Active power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
Q	Reactive power (total power)	Mvar	-	Reactive power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$
S	Apparent power (total power)	MVA	-	Apparent power of the primary values $\sqrt{3} \cdot V_{rated} \cdot I_{rated}$

Measured Values		Primary	Secondary	% Referenced to
Cos φ	Active power factor	(abs)	(abs)	100 % corresponds to cos φ = 1
P_A, P_B, P_C	Phase-related active power	MW	-	Active power of the phase $V_{rated\,\varphi} \cdot I_{rated\,\varphi}$
Q_A, Q_B, Q_C	Phase-related reactive power	Mvar	-	Reactive power of the phase $V_{rated\,\varphi} \cdot I_{rated\,\varphi}$
S_A, S_B, S_C	Phase-related apparent power	MVA	-	Apparent power of the phase $V_{rated\,\varphi} \cdot I_{rated\,\varphi}$

NOTE

With the P, Q sign parameter in the function block General of the respective function group, the sign of the following measured values can be inverted (see chapter 5.5 Function-Group Type Line in the subchapter 5.5.2 Structure of the Function Group, section on the **Inversion of Output-Related Measured and Statistical Values**):

- Active power (total): P total
- Active power (phase-related): P_A, P_B, P_C
- Reactive power (total): Q total
- Reactive power (phase-related): Q_A, Q_B and Q_C

9.4 Fundamental and Symmetrical Components

The fundamental components are calculated from the frequency-tracked instantaneous values through a Fourier filter (integration interval: one period). The results are phasor values that are described by way of the amount and phase angle.

In accordance with the transformation matrix, the symmetrical components are calculated from the voltage and current phasors. These are also phasor quantities.

Fundamental Components

Table 9-2 Fundamental Components

Values		Primary	Secondary	Phase Angle	% Referenced to
$\underline{V}_A, \underline{V}_B, \underline{V}_C$	Phase-to-ground voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_N$	Measured neutral-point displacement voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_{AB}, \underline{V}_{BC}, \underline{V}_{CA}$	Phase-to-phase voltage	kV	V	°	Rated operating voltage of the primary values
$\underline{I}_A, \underline{I}_B, \underline{I}_C$	Phase currents	A	A	°	Rated operating current of the primary values
$\underline{I}_N$	Neutral-point phase current	A	A	°	Rated operating current of the primary values

Symmetrical Components

Table 9-3 Symmetrical Components

Values		Primary	Secondary	Phase Angle	% Referenced to
$\underline{V}_0$	Zero-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_1$	Positive-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{V}_2$	Negative-sequence component of the voltage	kV	V	°	Rated operating voltage of primary values/√3
$\underline{I}_0$	Zero-sequence component of the current	A	A	°	Rated operating current of the primary values
$\underline{I}_1$	Positive-sequence component of the current	A	A	°	Rated operating current of the primary values
$\underline{I}_2$	Negative-sequence component of the current	A	A	°	Rated operating current of the primary values

9.5 Phasor Measurement Unit (PMU)

9.5.1 Overview of Functions

A Phasor Measurement Unit (PMU) measures the phasor values of current and voltage. These values get a high precision time stamp and together with the values of power frequency, power frequency change rate and optional binary data that are also time stamped are transmitted to a central analysis station. The standardized transmission protocol IEEE C37.118 is used to do this.

9.5.2 Structure of the Function Group

The PMU function group is activated by selecting the protocol IEEE C37.118 PMU on an Ethernet module (electrical or optical). The PMU obtains the measured values from the measuring points and the precise time from time synchronization. The time-stamped synchrophasors for current and voltage are formed from this and transferred together with additional values via the communication module to a server (PDC, Phasor Data Concentrator).

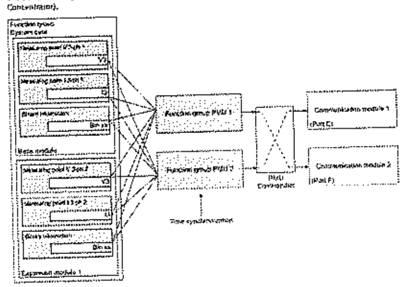


Figure 9-3 Structure/Embedding of the Function

9.5.3 Function Description

The synchrophasors, sent from the PMU in a continuous data stream to a PDC, are provided with time stamps and thus are comparable with the measured values of other PMUs. The power frequency, the power frequency change rate and optional binary information are also transmitted as time-stamped measured values. Therefore, you receive an overview of the transient processes in a distributed energy transfer system, for example network fluctuations and compensating processes.

The following table shows the differences between the PMU measured values and the remaining measured values of the device.

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Table 9-4 Comparison of Synchrophasors and Conventional Measured Values

Synchrophasors of the PMU	Measured Values from the Measuring Points
Continuous updating (measuring values of current with, for example, 10 values per second depending on rate)	Slow updating (typically every 5 seconds)
Every measured value has a time stamp	No time stamp for the measured values
Phasor values of current and voltage (amplitude and phase angle)	RMS values without phase angle

The following figure shows the structure of such a Wide Area Monitoring System. The data delivered from the PMUs on the PDC are transmitted via the Inter-Control Centre Communications Protocol (ICCP) according to [illegible] to the network control center.

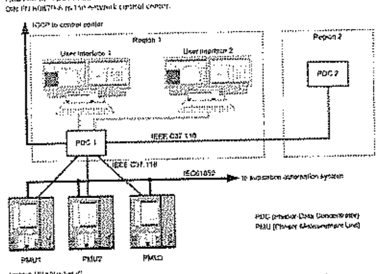

Figure 9-4 Structure of a Wide-Area Monitoring System with Phasor-Measurement Units

The phasor measurement units each have 2 communication interfaces: an Ethernet module for synchrophasor communication via IEEE C37.118 and another module for communication with the substation automation technology, for example, through the IEC 61850 protocol.

The central evaluation system, e.g. SIGUARD PDP Phasor Data Processor, receives the data, files, archives them and graphically displays them on a user interface. In this system, a self-checking function may also be performed, for example, on undamped power swings. The further distribution of information to other PDCs or to a control station is done here.

To maintain the required maximum errors (TVE) required in the standard IEEE C37.118, the time tolerance relative to the UTC time reference (UTC – Universal Time Coordinated) may be maximum 10 µs. Therefore, the device must be directly synchronized with a GPS precise time signal for the correct function of the PMU.

Phasors

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

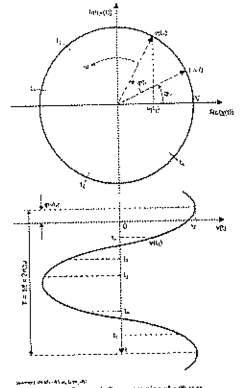

Figure 9-5 Geometric Representation of a Phasor

Reference Point for Determining the Angle

The phase angle of a measuring signal X_m is determined relative to a cosine function having a rated frequency, which is synchronized with the UTC time reference (see Figure 9-6).

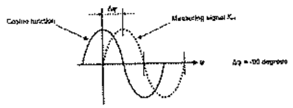

Figure 9-6 Determination of Phase Angle φ of Measuring Signal X_m Relative to the Cosine Function

The number of phasors that are transmitted per second is configurable. The transmission rate is defined according to IEEE C37.118 as the reporting rate. The reporting rate defines the number of phasors that are transmitted per second. Extremely slow or rapid synchronised [illegible] can be compared from different sites to be compared.

Reporting Rate

You use the configurable reporting rate (parameter (_:10621:102) Reporting rate) to specify the number of telegrams that are created and sent to the PDC per second. It is adjustable, depending on the rated frequency, and applies to all currents and voltages of the relevant PMU function group. If several PMU function groups are created on the device, these can work with different reporting rates.

Total Vector Error (TVE)

The TVE describes the error between the actual and the measured values of the input signal. The Synchrophasor Standard IEEE C37.118 defines upper limiting values of 120 % V_n and 200 % I_n, among other things. Up to these limiting values, the TVE of 1 % must not be exceeded for stationary signals. The standard divides the 2 performance classes, Class P and Class M, as ranges within which influencing variables are acceptable and the TVE of <1 % must be maintained. The SIPROTEC 5 devices support Class P and Class M, which specify the following influencing variables for a TVE of 1 %:

- Signal frequency (relative to f_n)
- Signal magnitude (relative to 100 % nominal magnitude) for voltage and current
- Phase angle (relative to UTC)
- Harmonic distortions (relative to < 0.2 % (THD) up to the 50th harmonic

The following figure graphically represents the total vector error. As well as the amplitude, the TVE also enters into the angle error.

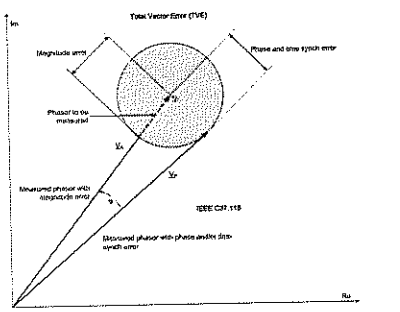

Figure 9-7 Representation of the Total Vector Error

The TVE is defined as follows.

$$TVE = \sqrt{\frac{(X_{r(n)} - X_r)^2 + (X_{i(n)} - X_i)^2}{X_r^2 + X_i^2}}$$

where,

- $X_{r(n)}$ = Real part of measured signal
- $X_{i(n)}$ = Imaginary part of measured signal
- X_r = Real part of input signal
- X_i = Imaginary part of input signal

Variables that influence the TVE are:

- Amplitude errors
- Phase errors
- Synchronization accuracy (deviation from the UTC)

Synchronization accuracy is affected by a GPS timer and the precise correction of the time delay within the GPS receiver module, as well as by the optimal setup of the GPS antenna.

9.5.4 Transmitted Data

The following data is transmitted from the PMU to the PDC:

- Current and voltage phasors
- Frequency
- Frequency rate of change
- Binary information

The current and voltage channels transferred from a PMU function group are selected through the Function group connections editor in DIGSI 5. The frequency and frequency change rate are determined once per PMU. In this case, only the current and voltage channels selected via the Function group connections editor for this PMU are taken into consideration. You may route the binary information in the information routing matrix of DIGSI 5.

The channel used for specifying the frequency is selected dynamically during the device runtime. Each channel is checked for the presence of a signal in the following order:

1. 3-phase voltage measuring points
2. 1-phase voltage measuring points
3. 3-phase current measuring points
4. 1-phase current measuring points

The 1st measuring point found with a valid signal is used for specifying the frequency in the PMU function group.

In the case of 3-phase measuring points, the positive-sequence system can also be transmitted instead of 3 individual synchrophasors. This setting can be made via the parameter (_:10621:103) Only positive sequence.

9.5.5 PMU Communication (IEEE C37.118)

PMU communication according to standard IEEE C37.118 is a client-server communication format in which the PDC (Phasor Data Concentrator) functions as both the client and the server.

Once the PDC has been successfully connected to the device PMU and the PMU configuration data has been queried, the PDC initiates transmission of the synchrophasor data by sending a close command to the PMU. In addition to the phasors, the channel names of the routed measuring points and the binary information are transferred. Per default, these are automatically generated by the respective PMU function groups.

Where applicable, you can also edit the channel names of the measuring point and assign a designation of its own for this purpose. For more information, see chapter 9.5.6 Parameterizing the PMU with DIGSI. The names for the binary information cannot, however, generally automatically generated by the respective PMU function group and cannot be edited.

As an example, the names (generated) for measuring points or binary information may be as follows:

Table 9-5 Possible Measuring-Point Names

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point V-3ph 1 (ID 1)	MP-V3ph VAB ID01 MP-V3ph VBC ID01 MP-V3ph VCA ID01 MP-V3ph VA ID01 MP-V3ph VB ID01 MP-V3ph VC ID01 MP-V3ph V1 ID01

Name Displayed in the DIGSI Function Group Connections	Depending on the Connection Type, Name Transferred to the PDC (in case it cannot be assigned automatically)
Measuring point I-3ph 1 (ID 2)	MP-I3ph IA ID02 MP-I3ph IB ID02 MP-I3ph IC ID02 MP-I3ph I1 ID02
Measuring point I-1ph 1 (ID 3)	MP-I1ph ID03
Measuring point V-1ph 1 (ID 4)	MP-V1ph ID03

Table 9-6 Possible Binary Information Names

Path Displayed in DIGSI 5 (Can Be Edited)	Name Transferred to the PDC (Cannot be Edited)
PMU 1: Transf.bin.1 >BinaryInfo.6	BIN-01-INFO-6
PMU 1: Transf.bin.2: >BinaryInfo.6	BIN-02-INFO-6
PMU 1: Transf.bin.10 >BinaryInfo.3	BIN-10-INFO-3

Data is transmitted continuously from the PMU to the PDC at the configured reporting rate. The transmission is terminated by a corresponding switch off command from the PDC or when the connection between the PDC and the PMU is interrupted.

Communication between the PMU and the PDC can be passed via TCP or UDP protocols.

The following ports are used for data transmission:

- TCP: Port 4712
- UDP: Port 4713

The ports must be configured on the PDC.

Up to 3 different PDCs can be connected to one device PMU at the same time. The IP addresses of the maximum 3 PDCs are set in the PMU function group. If 4 device PMUs are configured, this enables support for up to 12 PDCs.

9.5.6 Parametrizing the PMU with DIGSI

You configure and parameterize the Phasor-Measurement Unit with DIGSI. After a device has been added in a DIGSI project, one or more communication modules that support synchrophasors can be configured as PMUs. The device module supports a maximum of 2 communication modules that can be configured as PMUs. If more than 2 PMUs are needed, the device must be expanded with a CB202 plug-in module assembly (expansion module), which can accommodate 2 more communication modules.

The following communication modules support synchrophasors:

- ETH-BA-2EL (2 x Ethernet electric, RJ45)
- ETH-BB-2FO (2 x Ethernet optical, 2 km, LC duplex)

These modules are then freely assignable to ports E, F, N or P at the device, see Figure 9-8. You can view the selected port in the (_:10621:104) Port. This parameter is automatically managed by DIGSI and cannot be changed.

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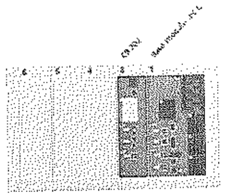

Figure 9-8 Placement of Communication Modules

> **NOTE**
>
> Port M of the CB202 plug-in module assembly is used to accommodate measuring transducer modules and cannot be used for the installation of communication modules.

Addressing

You must configure the respective Ethernet address (IP address, subnet mask, etc.) for each communication module in DIGSI. This is done in the DIGSI General settings properties dialog of the communication module. It uses Ethernet addresses and so forms the IP address for the respective PMU.

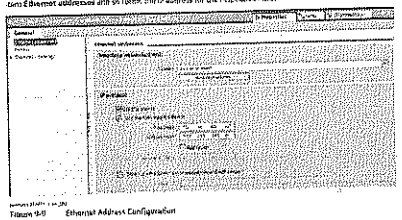

Figure 9-9 Ethernet Address Configuration

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

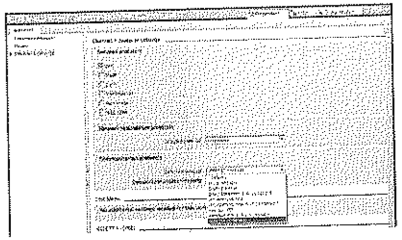

Figure 9-10 Protocol Selection

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

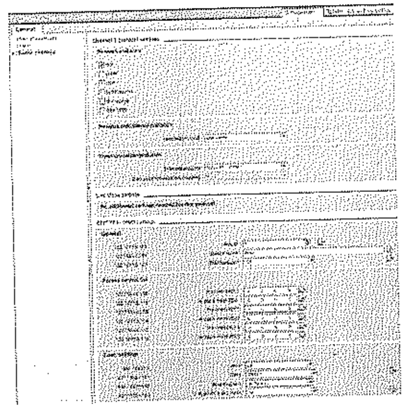

Figure 9-11 PMU-Specific Configuration

You configure the specific settings for the communication protocol in the top section of this settings dialog. In the bottom section, you specify the corresponding PMU specific settings.

In order to permit a better configuration of large wide area supervision systems, changes have been implemented in the IEEE C37.118 communication configuration that permit a flexible IP configuration without the loss of safety aspects in the systems administrated.

Configurable placeholders are permitted for each PDC IP address. These placeholders allow you to define a range of IP addresses where they are accepted within these addresses. The purpose of this is to permit each individual device or system access within the respective system without limits with regard to their hierarchy level. Therefore, with regard to security aspects, the limitation to individual IP addresses is eliminated. You are thus allowed to configure complete sections of IP addresses in each PMU and, as a result, very flexible when making changes to the configuration of the entire system. For example. The placeholder character must follow consecutively at the bit level, starting with the bit with the lowest value.

EXAMPLE of Placeholder Characters:

Example 1:

- binary 00000000.00000000.00000000.00101011 is not permitted
- binary 00000000.00000000.00000000.00111111 is permitted

Example 2:

- The PDC IP address is: 192.172.16.1
- Placeholder: 0.0.0.127

The device accepts requests within the IP address range of 192.172.16.1 to 192.172.16.127.

Example 3:

- The PDC IP address is: 192.172.16.100
- Placeholder: 0.0.0.3

The device accepts requests within the IP address range of 192.172.16.100 to 192.172.16.103.

If a PDC attempts to establish a connection to the device, the PDC IP addresses and corresponding placeholders are checked in the same order as they had been configured (IP address PDC1, IP address PDC2, IP address PDC3). Running through the list is stopped with the first match of the IP address, placeholder and requested IP address range and the connection is built up. If there are no matches, the attempt to connect is rejected.

If you have configured IP address 0.0.0.0 and the placeholder 255.255.255.255, every IP address received is accepted as valid. This could be of use in the course of commissioning measures.

> **NOTE**
>
> You must have configured at least 1 IP address in order to establish a connection between the device and PDC.

Measuring-Point Assignment

After adding measuring points to the device, you can assign these measuring points to each configured PMU. Figure 9-12 shows as an example expansion of the device configuration by 2 additional input/output modules. You connect the current and voltage inputs of these I/O modules to measuring points via the DIGSI routing matrix, see example in Figure 9-13.

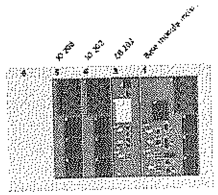

Figure 9-12 Adding Additional Input/Output Modules

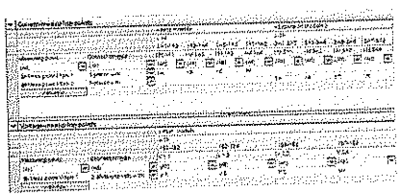

Figure 9-13 Assignment of the Current and Voltage Inputs of the Added Input/Output Modules on Measuring Points

The maximum numbers of measuring points that can be routed for one PMU are:

- 2 x 3-phase voltage measuring points
- 2 x 3-phase current measuring points
- 2 x 1-phase voltage measuring points
- 2 x 1-phase current measuring points

You can assign all supported measuring points to any PMU, see the following figure. However, each PMU must be connected to a 3-phase voltage measuring point.

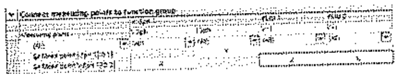

Figure 9-14 Connecting Measuring Points to the Configured PMU Function Groups

When these setting steps have been completed, the PMUs are fully configured. The PMU is a function group that functions independently of all the other function groups instantiated in the device.

The device load, however, is dependent on:

- Number of PMUs
- Performance class (where Class M generates the greater load)
- Number of assigned channels
- Configured reporting rate of each PMU
- Number of binary signals to be transferred

Changing the Channel Names of Phasors

You can edit the names of the individual phasor channels for voltage and current in DIGSI. The clearly structured channel designations assist with when testing and commissioning PMU systems. Furthermore, only the names visible in the IEEE C37.118 interface can be changed. The function block designations themselves cannot.

The IEEE C37.118 defines the ASCII character set for changing the channel names in the scope of the SIPROTEC 5 PMU support. Due to the protocol, the designation length is limited to 16 ASCII characters per channel. However, when renaming, you have to assign at least 1 character. The renaming of binary channels is not supported in the current implementation.

You can start the renaming by setting the check mark at Own phasor names with the parameterization in the PMU function block Functional settings. Once you have activated this check mark, define a separate name for each phasor. For this purpose, DIGSI shows all routed measuring points on the PMU in the function group connections (see following figure).

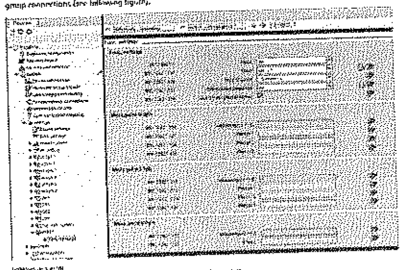

Figure 9-15 Options for Editing the Names of the Individual Phasors

> **NOTE**
>
> You can only rename each individual phasor when you set the parameter Positive-sequence system only to No in the functional settings. Otherwise you will only be offered one single phasor for each 3-phase measuring point for renaming.

Routing Binary Signals

You can connect binary inputs or CFC information with binary channels of the PMUs in DIGSI information routing. You will find, in the Phasor Measurement Unit (PMU) folder, the Binary information transmission function block in the DIGSI function library (see the following figure). You can instantiate this function block up to 10 times in one PMU function group. Each of these function blocks contains 8 options for routing binary channels.

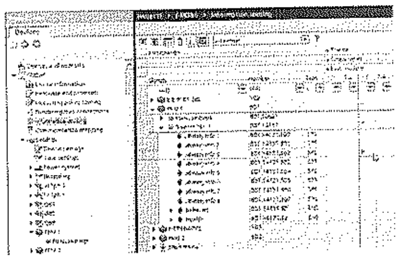

Figure 9-16 Information Routing in DIGSI 5

Routing Indications

The routable indication *Channel Live* of the PMU log

- raise when the PMU is connected to the PDC
- clears when the connection to the PDC is interrupted.

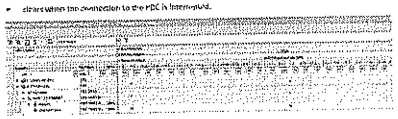

Figure 9-17 Log Indication for Display of the PMU/PDC Connection

9.5.7 Parameterizing the PMU on the Device

You can also change the PMU settings directly on the device. To do this, select the desired PMU instance on the device display. By selecting menu item Settings you then access the editable setting values (see Figure 9-18). Note that the parameter Port cannot be changed, because this corresponds to the physical slot position of the communication module in question.

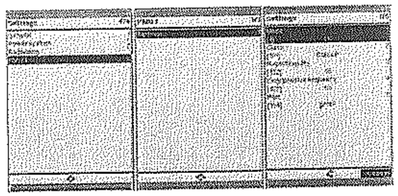

Figure 9-18 Changing the PMU Setting Values via the Device Display

You can also change the communication settings in the same way. To do this, select the corresponding communication port in the Communication menu on the device display. From the Channel 1 menu item, you can then access the detailed setting options for the IP or PMU communication settings (see Figure 9-19).

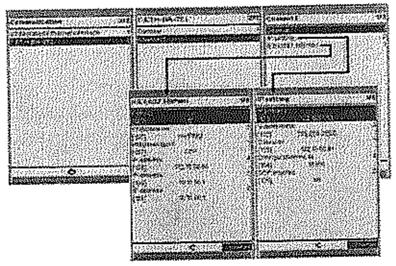

Figure 9-19 Changing the Communication Setting Values via the Device Display

9.5.8 Application and Setting Notes

Time Synchronization

In order to ensure the time accuracy of the PMU, you must select IRIG-B as protocol for the GPS clock, see the following figure. With other settings, the PMU function function group indicates that it is not time synchronized.

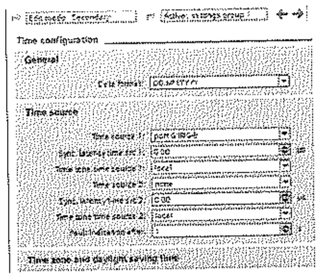

Figure 9-20 Setting Time Synchronization

To detect a lack of synchronization quickly, also set the waiting time for the failure indication of the loss of time synchronization to the smallest possible value, thus to 1 s.

Parameter: Mode

- Default setting (_:10621:1) Mode = on

Activate and deactivate the PMU or switch to test mode via the parameter Mode. The possible setting values are on, off and test. In Test mode, the PMU data is marked as invalid.

Parameter: Reporting rate

- Default setting (_:10621:102) Reporting rate = 10 frames/s

With the parameter Reporting rate, you specify the number of telegrams that are compiled and sent to the PDC per second.

> **NOTE**
> Different setting values are shown or hidden, depending on the rated frequency set.

Parameter: Only positive sequence

- Default setting (_:10621:103) Only positive sequence = no

With the parameter Only positive sequence, you set whether the positive sequence system is to be transmitted instead of 3 individual synchrophasors in the case of 3-phase measuring points. The setting you make here is then valid for all PMUs with 3-phase measuring points.

Parameter: Class

- Default setting (_:10621:101) Class = Class P

With the setting Class, you set which performance class is used for the calculation of the measured values. Class P is the standard case for PMUs. In this case, filters are used that are suitable for a short response time and therefore are well suited for recording dynamic processes. Class M is conceived for applications that are unfavorably affected by alias effects and in which short response times are not relevant.

Parameter: Port

This parameter cannot be set because the Port results from the physical position where the corresponding communication module is inserted.

9.5.9 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Func. settings				
_:10621:1	Func. settings:Mode		• off • on • test	on
_:10621:101	Func. settings:Class		• Class P • Class M	Class P
_:10621:102	Func. settings:Reporting rate		• 1 frames/s • 5 frames/s • 6 frames/s • 10 frames/s • 12 frames/s • 15 frames/s • 20 frames/s • 25 frames/s • 30 frames/s • 50 frames/s • 60 frames/s • 100 frames/s • 120 frames/s	10 frames/s
_:10621:103	Func. settings:Only positive sequence		• no • yes	no
_:10621:104	Func. settings:Port		• port J • port F • port E • port P • port N • port G •	port J
_:10621:105	Func. settings:Custom-ized phasor names		• 0 • 1	false

Addr.	Parameter	C	Setting Options	Default Setting
Meas.point V-1ph				
_:10621:130	Func. settings:Measuring point ID		0 to 0	0
_:10621:131	Func. settings:Phasor		Freely editable text	
Meas.point V-1ph				
_:10621:133	Func. settings:Measuring point ID		0 to 0	0
_:10621:134	Func. settings:Phasor		Freely editable text	
Meas.point I-1ph				
_:10621:136	Func. settings:Measuring point ID		0 to 0	0
_:10621:137	Func. settings:Phasor		Freely editable text	
Meas.point I-1ph				
_:10621:139	Func. settings:Measuring point ID		0 to 0	0
_:10621:140	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:106	Func. settings:Measuring point ID		0 to 0	0
_:10621:107	Func. settings:Phasor 1		Freely editable text	
_:10621:108	Func. settings:Phasor 2		Freely editable text	
_:10621:109	Func. settings:Phasor 3		Freely editable text	
_:10621:111	Func. settings:Phasor		Freely editable text	
Meas.point V-3ph				
_:10621:112	Func. settings:Measuring point ID		0 to 0	0
_:10621:113	Func. settings:Phasor 1		Freely editable text	
_:10621:114	Func. settings:Phasor 2		Freely editable text	
_:10621:115	Func. settings:Phasor 3		Freely editable text	
_:10621:117	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:118	Func. settings:Measuring point ID		0 to 0	0
_:10621:119	Func. settings:Phasor 1		Freely editable text	
_:10621:120	Func. settings:Phasor 2		Freely editable text	
_:10621:121	Func. settings:Phasor 3		Freely editable text	
_:10621:123	Func. settings:Phasor		Freely editable text	
Meas.point I-3ph				
_:10621:124	Func. settings:Measuring point ID		0 to 0	0
_:10621:125	Func. settings:Phasor 1		Freely editable text	
_:10621:126	Func. settings:Phasor 2		Freely editable text	
_:10621:127	Func. settings:Phasor 3		Freely editable text	
_:10621:129	Func. settings:Phasor		Freely editable text	

9.5.10 Information List

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

833

9.6 Average Values

9.6.1 Function Description of Average Values

Average values can be formed based on different measurands:

- Operational measured values
- Symmetrical components

Through the settings, you can set how and when the average values are formed. The settings describe:

- Time slot over which the average value is formed
  (Parameter: `Average calc. interval`)
- Update interval for the display of the average values
  (Parameter: `Average update interval`)
- Synchronization time for establishing the date of commencement updating information, for example, at the top of the hour (hh:00) or at one of the other times (hh:15, hh:30, hh:45).
  (Parameter: `Average synchroniz. time`)

Average values are formed through the following measurands:

- Operational measured values except for phase-related settings
- Amounts of the symmetrical components

You reset the average value formation via the

- Binary input >Reset average value
- DIGSI
- The integrated operation panel

> **NOTE**
>
> With the `P, Q sign` parameter in the function block General, the sign of the following measured values of the respective function group can be inverted (see Chapter 2.2 Structure of the Function Structure of the Function, section Inversion of Output-Related Measured and Statistical Values):
>
> - Active power (total): P total
> - Reactive power (total): Q total

9.6.2 Application and Setting Notes for Average Values

The average value formation functionality is not preconfigured with the devices in the function group. If you use the functionality, you must load it from the library into the respective function group.

The following settings listed for the calculation of the average values can be set with DIGSI and at the device. You find the setting parameters in DIGSI in the project tree under Settings > Device settings.

Parameter: Average calc. interval

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

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

Parameter: Average update interval

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

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

Parameter: Average synchroniz. time

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

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

> **NOTE**
>
> The average value calculation restarts after
>
> - Changing one of the 3 settings for the average value calculation
> - Resetting the device (initial or normal reset)
> - Changing the time
> - Resetting the average values
>
> The average values are reset immediately. The display changes to "---".

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

`Average calc. interval` = 60 min
`Average update interval` = 30 min
`Average synchroniz. time` = hh:45

A new average value is formed every 30 min, at hh:15 (15 min after the top of the hour) and hh:45 (15 min before the top of the hour). All measured values obtained during the last 60 min are used for average value formation.

If these settings are changed to 11:03:25, for instance, the average values are first reset and "---" appears in the display. The 1st average value is then formed at 12:15:00.

In this example, the `Average synchroniz. time` = hh:45 acts as described above for = hh:15.

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

A new average value is formed every 60 min at hh:15 (15 min after the top of the hour). All measured values obtained during the last 60 min are used for average value formation.

If these settings are changed to 11:30:25, 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.

9.7 Minimum/Maximum Values

9.7.1 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.

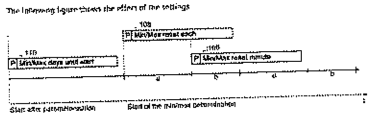

Figure 9-21 Minimum and Maximum Value Formation

Minimum and maximum values are time stamped.

Minimum/maximum values are formed through:

- Operational measured values except for phase-related settings
- 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 2.2 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

9.7.2 Application and Setting Notes for Minimum/Maximum Values

The minimum/maximum values functionality is not preconfigured. If you want to use the functionality, you must load it from the library into the respective function group.

The following settings listed for the calculation of the minimum/maximum values can be set with DIGSI or at the device. You find the setting parameters in DIGSI in the project tree under Settings > Device settings.

Parameter: Min/Max cyclic reset

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

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

Parameter: Min/Max reset each

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

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

Parameter: Min/Max reset minute

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

Parameter Value	Description
0 min to 1439 min	Resetting the maximum value and the minimum 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 at 1 day (after the parameterization)

9.8 Energy Values

9.8.1 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:

$$\text{Energy metered value} = \frac{\text{Energy value}}{S_{rated}} \cdot 10000 \frac{\text{Pulses}}{h}$$

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 logic.
  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 suitable binary input (>Restore Eng). 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 Eng) 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 0, -0 as an parameter in the Insert on block General, the sign of the following measured values of the respective function group can be inverted (see Chapter 2.2 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+

9.8.2 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 = false

Parameter Value	Description
false	Restoring deactivated

Parameter Value	Description
true	The cyclic restoring after the settings 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.

9.9 User-Defined Metered Values

9.9.1 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 9-22). Select the metered value and enter the settings under Properties.

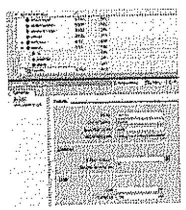

Figure 9-22 Setting with DIGSI, General Settings, Pulse-Metered Values

9.9.2 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: (_:102) 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: (_:107) 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 routing. 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.

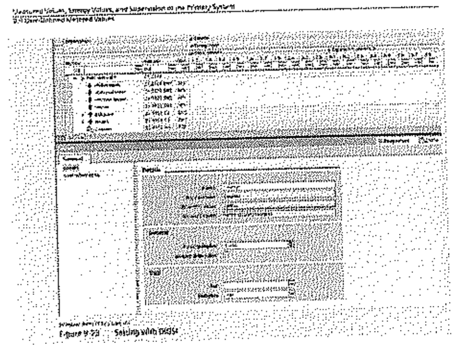

Figure 9-23 Setting with DIGSI

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9.10 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)

9.11 Measuring Transducers

9.11.1 Overview of Functions

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

9.11.2 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.

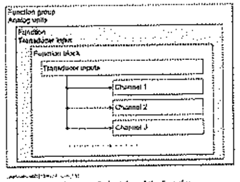

Figure 9-24 Structure/Embedding of the Function

9.11.3 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.

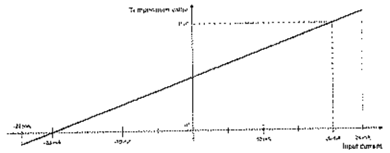

Figure 9-25 Characteristic Curve of a 20-mA Input (Example 1)

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 = 200 are entered. The resolution (decimal place) of the temperature value can be chosen; for a decimal place, select Resolution = 0.1.

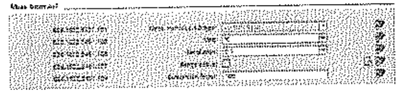

Figure 9-26 Settings for Example 1

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

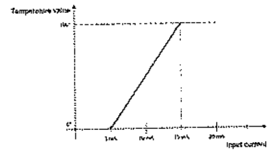

Figure 9-27 Characteristic Curve of a 20-mA Input (Example 2)

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

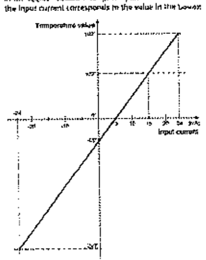

Figure 9-28 Total Characteristic Curve in Example 2

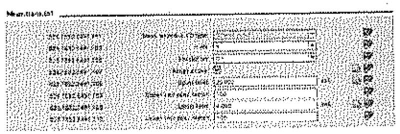

Figure 9-29 Settings for Example 2

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.

9.11.4 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.

9.11.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MT in #				
_:101	MT in #:MeasTransducer I/O type		Current input	Current input

Addr.	Parameter	C	Setting Options	Default Setting
_:103	MT in #:Unit		• % • ° • °C • °F • G • 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 • km • 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	MI in d Lower limit - Sensor		-10000 to 10000	100

9.11.6 Information List

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

9.12 Circuit-Breaker Wear Monitoring

9.12.1 Overview of Functions

The Circuit-breaker wear monitoring function:

- Records the wear of circuit breakers
- Allows the 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.

9.12.2 Structure of the Function

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

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

- ΣI*-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.

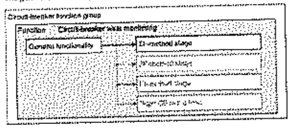

Figure 9-30 Structural Embedding of the Function

9.12.3 General Functionality

9.12.3.1 Description

Logic

As the wear on the circuit breaker depends on the current amplitude and duration of the actual switching action, including arc extinction, 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.

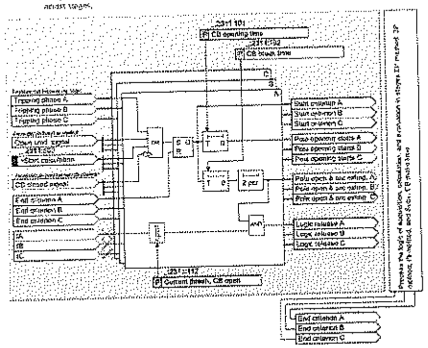

Figure 9-31 Logic Diagram of the Functionality Across Stages of the Circuit-Breaker Wear Monitoring Function

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.

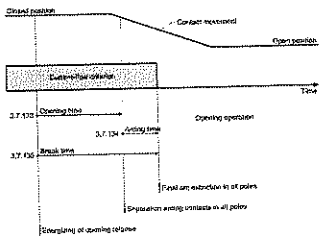

Figure 9-32 Circuit-Breaker Times

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.

9.12.3.2 Application and Setting Notes

Parameter: CB opening time

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

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

You can find the information on the setting value in the technical data of the used circuit breaker. Also refer to Figure 9-32.

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 (end 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 9-32.

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.

9.12.3.3 Settings

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

9.12.3.4 Information List

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

9.12.4 Stage Description ΣI* Method

9.12.4.1 Description

Logic of the Stage

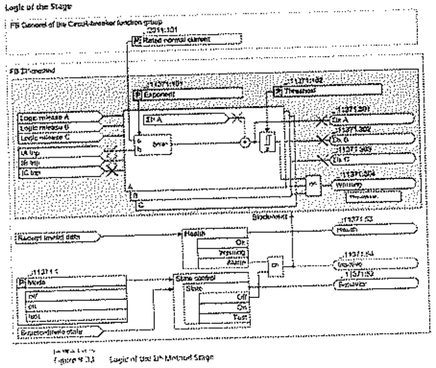

Figure 9-33 Logic of the ΣI* Method Stage

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 pending pole opening starts criterion, the latest value in the buffer is searched for whose value is above the setting of parameter Current thresh. CB open. The 20 ms prior value is used as tripping/opening current for further calculation.

If no value within the buffer is above the setting value, the circuit-breaker opening affects only the mechanical lifetime of the circuit breaker and is consequently not considered by this method.

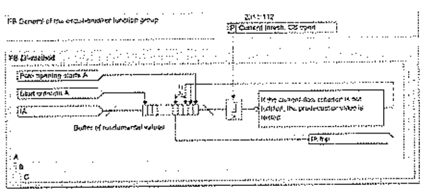

Figure 9-34 Logic of the Determination of the Tripping Current Value

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

Calculation of the Wear

If the ΣI^x-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^x method as follows, with phase A as example.

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

Where

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

The phase-selective ΣI^x 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^x value of any phase is greater than the threshold, a phase-selective warning signal is generated.

9.12.4.2 Application and Setting Notes

Parameter: Exponent

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

You use the Exponent parameter to specify the exponent for the ΣI^x 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 ΣI^x 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.

9.12.4.3 Settings

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

9.12.4.4 Information List

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

9.12.5 Stage Description 2P Procedure

9.12.5.1 Description

Logic of the Stage

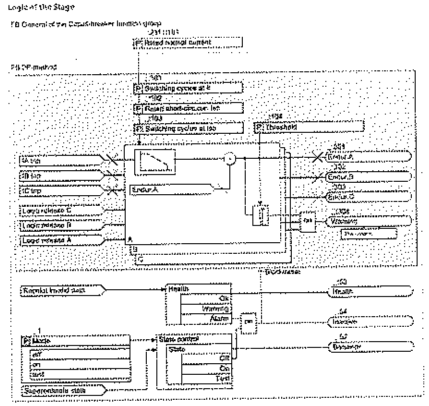

Figure 9-35 Logic of the 2P-Method Stage

Determination of the Tripping/Opening Current Value

For the description to determine the tripping/opening current value, refer to chapter 9.12.4.1 Description.

Calculation of Remaining Switching Cycles

A double-logarithmic diagram provided by the circuit-breaker manufacturer illustrates the relationship of permitted switching cycles and the tripping/opening current, see the following figure. According to the example, this circuit breaker can operate approximately 1000 times at a tripping current of 10 kA.

2 points and their connecting line determine the relationship of switching cycles and tripping current. Point P1 is determined by the number of permitted switching cycles at rated normal current I_{rated}. Point P2 is deter-

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

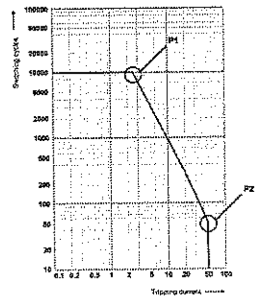

Figure 9-36 Diagram of Switching Cycles for the 2P Method

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.

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

Where

I_{tip}	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.

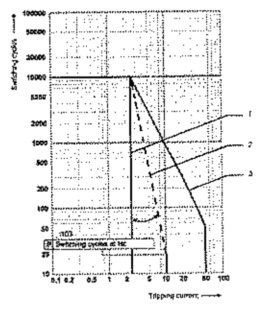

Figure 9-37 Value Limitation of Slope Coefficient

(1) Applied function from m = -4
(2) Parameterized function with m = -4.48
(3) Parameterized function with m = -3.77

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

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

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

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

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_{tip}	Overall permissible switching cycles at tripping current I_{tip}
n_{rated}/n_{tip}	Lost switching cycles referring to rated normal current

EXAMPLE

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

P1 (2.5 kA, 10 000)

P2 (50.0 kA, 50)

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

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

$$= 10000 - \left(100 \cdot \frac{10000}{10000}\right) - \left(2 \cdot \frac{10000}{50}\right) - \left(3 \cdot \frac{10000}{861}\right) = 9465$$

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

Circuit-Breaker Maintenance Warning

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

9.12.5.2 Application and Setting Notes

Parameter: Switching cycles at Ir

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

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

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

Parameter: Rated short-circ.cur. Isc

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

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

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

Parameter: Switching cycles at Isc

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

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

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

Parameter: Threshold

- Default setting (_:103) 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 number 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:

$3 \cdot \frac{10000}{50} = 600$

9.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
2P-method				
_:1	2P-method:Mode		• off • on • test	off
_:101	2P-method:Switching cycles at Ir		100 to 1000000	10000
_:102	2P-method:Rated short-circuit 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

9.12.5.4 Information List

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

9.12.6 Stage Description I²t Method

9.12.6.1 Description

Logic of the Stage

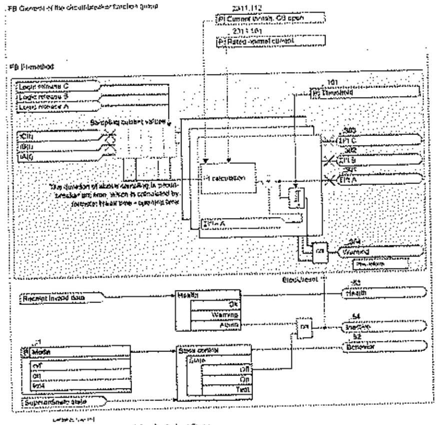

Figure 9-38 Logic of the I²t Method Stage

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 9-37). The stage determines the ending point of the arc time by searching backward the zero-crossing point of the phase currents after it receives the logic release signal. Then, the squared fault currents during the arc time are integrated phase-

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

$$\Sigma I^2t_A = \frac{1}{I_{rated}^2} \int_{Start arc time}^{Stop arc time} i_A^2(t)dt$$

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.

9.12.6.2 Application and Setting Notes

Parameter: Threshold

- Default setting (_:101) Threshold = 10 000.00 I/Ir*s

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

9.12.6.3 Settings

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

9.12.6.4 Information List

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

9.12.7 Stage Description Supervision CB Make Time

9.12.7.1 Description

Logic of the Stage

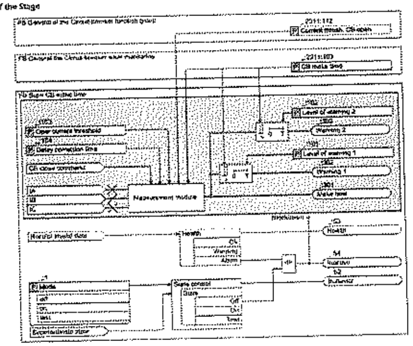

Figure 9-39 Logic of the Supv.CB Make-Time Stage

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.

9.12.7.2 Application and Setting Notes

Parameter: Level of warning 1

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

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

Parameter: Level of warning 2

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

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

Parameter: Oper. current threshold

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

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

Parameter: Delay correction time

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

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

9.12.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Supv.CB make time				
_:1	Supv.CB make time:Mode		• off • on • test	off
_:101	Supv.CB make time:Level of warning 1		1 % to 100 %	5 %
_:102	Supv.CB make time:Level of warning 2		1 % to 100 %	10 %
_:103	Supv.CB make time:Oper. current threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:104	Supv.CB make time:Delay correction time		0.050 s to 0.050 s	0.000 s

9.12.7.4 Information List

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

10 Functional Tests

10.1 General Notes

Various tests have to be performed for commissioning to ensure the correct function of the device. For tests using secondary test equipment, make sure that no other measured values are connected 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 operating utility. The described tests require that these be capable of being performed safely. They are not conceived for operational checks.

10.2 Checking System Integration

In addition to the protection setting and the correct routing of the signals, proper system integration is important. When checking the system integration, Siemens recommends the following procedure:

- ✧ The device must placed in the operating area at least 2 hours before you apply voltage for the first time. By allowing thermal equilibrium to be established, you avoid moisture and condensation at the device. Perform the connection checks on a completely installed device with the system switched off and grounded.

You will find connection diagrams in the circuit-breaker manual and/or in the manual Engineering Guide. Also observe the connection diagrams in the Appendix A.4 Standard Variants for 7UT82, A.5 Standard Variants for 7UT85, 7UT86, A.6 Standard Variants for 7UT86 and A.7 Standard Variants for 7UT87.)

Proceed as follows in order to check the system connections:

⚠ **DANGER**

Hazardous voltages.

Noncompliance with the following measures can lead to death, serious physical injury or significant material damage.

- ✧ Only qualified individuals who are familiar with and follow the safety regulations and precautionary measures may perform checks.

⚠ **CAUTION**

Exercise caution when operating the device without a battery on a battery charging device.

Noncompliance with the following measures can cause impermissibly high voltages and, as a result, destruction of the device.

- ✧ Do not operate devices on a battery charging device without a battery connected if you will find limiting values in the Technical Data).

- ✧ Switch off the circuit breaker for the supply auxiliary voltage and the measuring voltage.

Measure all current and voltage transformer supply cables according to system and connection diagrams:

- ✧ Check the connections of all sets of 3-phase current transformers at the device inputs. Are they connected correctly and do they match the configuration (measuring point assignment)?
- ✧ Check the connections of all sets of 1-phase current transformers to the device inputs. Are they connected correctly and do they match the configuration?
- ✧ Check whether the grounding of the current transformer is correct. Grounding in the direction of the protected object is preferred.
- ✧ Check whether the polarity of the current transformer connections is identical in each set of transformers.
- ✧ Check whether the phase allocation of all sets of 3-phase current transformers is correct.
- ✧ Check whether the polarity of all sets of 1-phase current transformers is correct (if used).
- ✧ Check whether the grounding of the voltage transformer is correct (if used).
- ✧ Check whether the polarity of the voltage transformer connections is identical and correct (if used).
- ✧ Check whether the phase allocation of the voltage transformer is correct (if used).
- ✧ If the test switch for the secondary test of the device is used, check its function.

NOTE

Ensure that the current transformer secondary connection cables are automatically short-circuited in the setting Test.

- ✧ Loop the ammeter into the supply line for auxiliary voltage and select a range from 2.5 A to 5 A.
- ✧ Switch on the circuit breaker for the supply auxiliary voltage.
- ✧ Check the voltage level and polarity on the device terminals or the connection modules.

The current consumption must correspond to the quiescent power consumption of the device. A short swing of the phaser is uncritical and displays the charging current inrush to the storage capacities.

- ✧ Switch off the circuit breaker for the supply auxiliary voltage.
- ✧ Remove the ammeter and restore the normal auxiliary voltage connection.
- ✧ Switch on the voltage-transformer circuit breaker (if used).
- ✧ Check the direction of the rotating field at the device terminals.
- ✧ Switch off the circuit breaker for the transformer voltage and supply auxiliary voltage.
- ✧ Check the trip lines to the circuit breakers.
- ✧ Check the control lines from and to other devices.
- ✧ Check the signaling wires.
- ✧ Switch on the circuit breaker for the transformer voltage and supply auxiliary voltage again.

10.3 Commissioning Notes Transformer Differential Protection

10.3.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following 10.3.2 Primary Tests, because they cannot include connection faults.

Secondary tests serve the following purposes:

- Checking the setting values
- Proper response of protection function
- Engineering (processing of the respective logic signals, display images with measured values, logic circuits in CFC and others)

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

NOTE

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

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

NOTE

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

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

NOTE

Tests of currents via quadruple device-rated current (or a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find more information in chapter 11.2 Transformer Differential Protection. Interrupt testing to allow cool-down!

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

If you are testing parameters set during operation, you must ensure that the setting value for the differential protection refers to the rated current of the protected object. The rated current is the primary current that results formally from:

$$I_{rated,obj} = \frac{S_{rated,obj}\,[MVA] \cdot 1000}{\sqrt{3} \cdot V_{rated,obj}\,[kV]}\,[A]$$

$S_{rated,obj}$	Rated apparent power of the protected object
$V_{rated,obj}$	Rated voltage of the protected object or the winding being observed

For a winding with voltage control, the calculated voltage applies in accordance with 6.2.4 Application and Setting Notes.

For transformers, the actual pickup values for 1-phase or 2-phase testing also depend on the vector group of the transformer. For 1-phase testing, the pickup values also depend on the treatment of the winding neutral point and the processing of the neutral point current.

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

$$\frac{I_{rated,wind.}}{I_{rated,transf.,prim}} \cdot k_{SG}$$

The following table shows this factor k_{SG} for each vector group and the fault type in 3-phase transformers.

Table 10-1 Correction factor k_{SG} for the vector group (SG) and fault type

Fault type	Reference winding (high voltage)	Even SG number (0, 2, 4, 6, 8, 10)	Odd SG number (1, 3, 5, 7, 9, 11)
3-phase	1	1	1
2-phase	1	1	$\sqrt{3}/2 \approx 0.866$
1-phase with I_0 elimination	$3/2 = 1.5$	$3/2 = 1.5$	$\sqrt{3} \approx 1.73$
1-phase without I_0 elimination	1	1	$3/(1+\sqrt{3}) \approx 1.1$

Example:

3-phase transformer	S_{rated} = 57 MVA
Vector group	Yd5
High voltage	V_{rated} = 110 kV
Current transformer	300 A/1 A
Undervoltage	V_{rated} = 25 kV
Current transformer	1500 A/1 A

The following applies to the upper-voltage winding:

$$I_{rated,wind.} = \frac{S_{rated,transf.}\,[MVA] \cdot 1000}{\sqrt{3} \cdot V_{rated,winding}\,[kV]}\,[A] = \frac{57\,[MVA] \cdot 1000}{\sqrt{3} \cdot 110\,[kV]}\,[A] = 299\,A$$

Here the rated current of the winding ≈ rated current of current transformer. Thus, for a 3-phase or 2-phase test, the pickup value corresponds to the setting value (threshold value of the device k_{SG} = 1 for reference winding) with reference to the device rated current. For the threshold value the designation IDIFF> is used. For a 1-phase test with residual current elimination, 1.5 times the value is to be expected as a pickup value.

The following applies to undervoltage:

$$I_{rated,wind.} = \frac{S_{rated,transf.}\,[MVA] \cdot 1000}{\sqrt{3} \cdot V_{rated,winding}\,[kV]}\,[A] = \frac{57\,[MVA] \cdot 1000}{\sqrt{3} \cdot 25\,[kV]}\,[A] = 1316\,A$$

For the secondary test of this winding, the theoretical pickup value refers to device's rated current:

$$\frac{I_{pickup}}{I_{rated,device}} = \frac{I_{rated,wind.}}{I_{rated,transf.,prim}} \cdot k_{SG} \cdot IDIFF> = \frac{1316\,A}{1500\,A} \cdot k_{SG} \cdot IDIFF>$$
$$= 0.877 \cdot k_{SG} \cdot IDIFF>$$

Due to the odd vector group numbers, the following pickup values apply (see Table 10-1):

1-phase $k_{SF} = 1$

$\frac{I_{sense}}{I_{rated\,device}} = 0.577 \cdot IDIFF>$

2-phase $k_{SF} = \sqrt{3}/2$

$\frac{I_{sense}}{I_{rated\,device}} = 0.750 \cdot IDIFF>$

3-phase $k_{SF} = \sqrt{3}$

$\frac{I_{sense}}{I_{rated\,device}} = 1.52 \cdot IDIFF>$

10.3.2 Primary Tests

If secondary test equipment is connected to the device, remove it and switch the test switch to the operating position.

> **NOTE**
> Be aware that a trip results in case of incorrect connections.

Preparation of Current Tests

So that the differential protection is effective as short-circuit protection for the first excitation of the protected object under a voltage load, perform the current tests in the case of initial commissioning before switching on the voltage for the first time. If the current tests are possible only when the protected object is switched on, for example, with network transformers when no test source for low voltage is available, then commission an external backup protection on the supply side first, for example, overcurrent protection. This backup protection works on the supply circuit breaker. The trip circuits of other protection equipment, for example, Buchholz protection, must also remain active.

Repeat the current tests in the case of protected objects with more than 2 measuring points. All sides of the protected object must be included at least once in the current flow test. You do not have to check every possible current path. Siemens recommends beginning with measuring point 1 of the main protected object and testing it against each of the others. When a side has more than measuring point, you must include each at least once in the test. The remaining measuring points carry no current.

If other 1-phase protected objects are present, these are checked separately in accordance with their topology.

The test setup varies, depending on the use case.

> **DANGER**
> Dead components hazardous due to capacitive coupling of other system parts!
> **Failure to comply with the safety notes, can result in death, severe injury or considerable material damage.**
> - Primary tests may be performed only on dead and grounded system parts!

- Preferably, perform a undervoltage test on network transformers and asynchronous machines in which the protected object (transformer) from the line is supplied with current by a test source for low voltage. This symmetrical test source produces the test current via a suitable 2-pole cross connector externally incorporated to the protection range or via the motor neutral point. The test current source is connected to transformers on the upper-voltage side, the 2-pole cross connector on the low-voltage side.

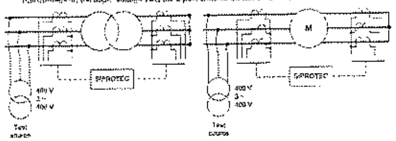

Figure 10-1 Test Setup with Low-Voltage Source – Example of Transformer and Motor

- For generator transformers and synchronous machines, perform the tests for short-circuits, with the machine itself serving as test current source. The test current is produced locally by means of a suitable 2-pole cross connector incorporated externally to the protection range, with generator's rated current.

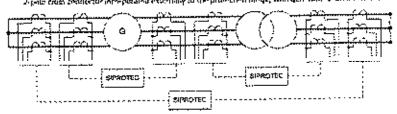

Figure 10-2 Test Setup in Power System with Generator as Voltage Source – Example

Performance of Current Tests

- Before you begin with the first current test, check the polarity setting for the measuring points and compare them to the actual current connections.
  For the commissioning tests, a flowing current of at least 2 % of the device's rated current per phase is necessary.

> **NOTE**
> These tests cannot replace a visual check of the correct current transformer connections. Completed checks of the system connections are therefore a prerequisite.

The SIPROTEC 5 device makes operational measured values available. With these operational measured values, quick commissioning without external instrumentation is possible.

The following procedure is intended for 3-phase protected objects, namely, for measuring point 1 against measuring point 2. For transformers, it is assumed that side 1 is the upper-voltage side of the transformer. The remaining possible current circuits are tested analogously.

- Switch the test current on, or bring the generator to rated speed and excite it to test current. Acquisition of measured values in the SIPROTEC 5 device must not cause pick up. If a failure indication is present, you can see in the logs what causes came into question.
  – In the case of indications from balance supervision, the primary system may actually be unbalanced. If this is a normal operating condition, then set the corresponding supervision function to be less sensitive.
  – The rotating field is clockwise for test sequence A, B, C). If the line has a phase sequence A, C, B, you must account for this when setting the power-system data. Incorrect direction of rotation is indicated. Check the phase assignment of the measurands and correct the affected measuring point after switching off, then repeat the measurement.

Amount Measurements with Test Current Switched On

Compare the currents displayed by the device under **Operational measured values** with those actually flowing.

This applies to all measuring points that belong to the tested current path. If deviations result which cannot be explained through measuring tolerances, there is a connection fault or an error in the test setup.

- Switch off the test source and the protected object. Ground the protected object or shut down the generator.
- Check the assignment of the measuring point currently being tested.
- Check the parameters for the compensation.
- Check and correct the connections and test setup.
  If a considerable ground current 3I0 occurs, the polarity of individual phases has been reversed at the corresponding measuring point:
  3I0 = phase current → 1 or 2 phase currents are missing;
  3I0 = double phase current → 1 or 2 phase currents are reversed;
- Repeat the measurement and check the amounts again.

Angle Measurement for Measuring Point 1 with Test Current Switched On

- Check the angles displayed by the device for measuring point 1 under **Measured values**. All angles refer to I_A.
  The following results must appear:
  $\varphi_A = 0°$
  $\varphi_B = 240°$
  $\varphi_C = 120°$
  If the angles are not correct, polarity faults are present in the connection of individual phase currents at the measuring point.
- Switch off the test source and the protected object. Ground the protected object or shut down the generator.
- Check and correct the connections and test setup.
- Repeat the measurement and check the angles.

Angle Measurement for Measuring Point 2 with Test Current Switched On

- Check the angles displayed by the device for measuring point 2 under **Measured values**. All angles refer to I_A.
  Ensure that the currents into the protected object are always defined as positive. If the test current flows through, currents of the same phase at measuring point 2 are shifted by 180° with respect to measuring point 1.
  The following results must appear:
  $\varphi_A = 180°$
  $\varphi_B = 60°$
  $\varphi_C = 300°$
  Measured via a transformer, depending on the vector group, approximately the results according to the following table.
  If the angles are not correct, polarity faults are present in the connection of individual phase currents at the measuring point.

Table 10-2 Angle Display Depending on Protected Object (3-Phase)

Phase Angle	Protected Object: Generator/Motor/short line	Transformer with vector group numbers[4]: 0	1	2	3	4	5	6	7	8	9	10	11
φ_{A2}	180°	180°	150°	120°	90°	60°	30°	0°	330°	300°	270°	240°	210°
φ_{B2}	60°	60°	30°	0°	330°	300°	270°	240°	210°	180°	150°	120°	90°
φ_{C2}	300°	300°	270°	240°	210°	180°	150°	120°	90°	60°	30°	0°	330°

If the angles are not correct, there are polarity faults or a phase inversion in the connection of measuring point 2 or the other side to be tested at the tested measuring point.

- If deviations are present in individual phases, a polarity fault is present in the connection of these phase currents or an acyclic phase inversion is present.
- If all angles deviate by the same amount, there is a cyclic inversion of all 3 phases or an incorrect vector group in transformers. In the last case, check the vector group adaptation. Also pay attention to the assignment of the measuring points to the sides and the assignment of the sides to the protected object.
- If all angles differ by 180°, the polarity of a set of current transformers for the second measuring point is not correct. You can fix this by testing and correcting the corresponding parameters of the substation configuration.

If you presume a connection fault,

- Switch off the test source and the protected object. Ground the protected object or shut down the generator.
- Check and correct the connections and test setup.
- Check the settings for the corresponding current transformer data.
- Repeat the measurement and check the angle.

Repeat all tests previously described until all measuring points for the main protected object are included in a test at least once.

Measuring Differential and Restraint Currents

To complete the symmetrical tests, check the differential and restraint current measurements. If the previous symmetrical measurements also reveal the connection faults, errors in the adaptation and in the vector group assignment cannot be excluded.

[4] For upper-voltage side defined as side 1, the angles are valid. Otherwise, 360° minus the stated angle is valid.

The differential and restraint currents refer to the rated current of the protected object. Observe this when comparing the test currents. For more than 2 sides, the rated current of the protected object equals the highest rated current of all sides of the protected object.

- Read out the differential and restraint currents under **Measured values**.
  – The differential currents IDIFFA, IDIFFB, IDIFFC must be low, at least one order of magnitude less than the test currents flowing through. Ideally, they are 0.
  – The restraint currents IStabA, IStabB, IStabC correspond to the test current flowing through.
  – If differential currents occur on the order of magnitude of the restraint currents, there is a possibly reversal in the current transformer or current transformers on one side. Again check the polarity and correct it after short-circuiting all 6 current transformers. If you have made changes to current transformers, repeat the angle test.
  – If substantial differential currents occur that are approximately the same in all phases, a faulty adaptation of the measurands is present. Faults in the vector group adaptation in transformers are already discovered in the winding test. Check the settings of the device relevant for current adaptation. These are the data of the protected object.
- Finally, switch off the test source and the protected object or shut down the generator.
- If parameter settings have been changed for the tests, reset them to the values necessary for operation.

> **NOTE**
> Ensure that you perform the intended tests for each current path.

Residual-Current Test on the Protected Object

If the neutral point of a winding or side is grounded in the case of 3-phase protected objects, the following residual-current tests are required. If several neutral points are grounded, you must perform the residual-current tests for each of the grounded windings.

- If the neutral-point current is available and is connected to the device via a 1-phase current input, the polarity of the ground current connection is essential for taking the neutral point current into account. This applies to the differential and restricted ground-fault protection.
- If no neutral point current is available, the residual-current tests serve to verify the correct treatment of the residual currents in the differential protection.

> **NOTE**
> Be aware that a trip results in case of incorrect connections.

Preparation of the Residual-Current Tests

- Perform the residual-current measurements from the side or 3-phase measuring point for which the neutral point is grounded. For auto transformers, perform the measurement from the upper-voltage side. For transformers, a delta winding must be present (delta winding or stabilizing winding). The windings not included in the test remain open, since the delta winding creates the impedance of the residual-current path by itself.

The test setup varies, depending on the use case. Figure 10-3 to Figure 10-9 schematically show an example of the test setup on a grounded star-delta transformer. The neutral-point current is included in the measurement. If the neutral point is not accessible, it is left out (compare Figure 10-3 with Figure 10-4).

> **DANGER**
> Dead components hazardous due to capacitive coupling of other system parts!
> **Failure to comply with the safety notes, can result in death, severe injury or considerable material damage.**
> - Primary tests may be performed only on dead and grounded system parts!

- Observe the following examples for measuring residual current.

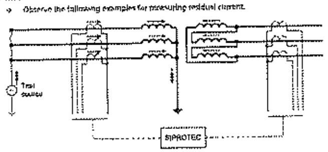

Figure 10-3 Measurement of Residual Current on a Star-Delta Transformer – Without Neutral-Point Current Measurement

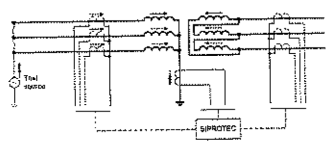

Figure 10-4 Residual Current Measurement on a Star-Delta Transformer

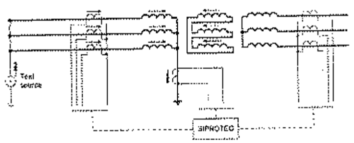

Figure 10-5 Residual-Current Measurement on a Star-Delta Transformer with Stabilizing Winding

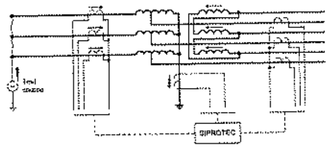

Figure 10-6 Residual-Current Measurement on an Auto Transformer with Stabilizing Winding

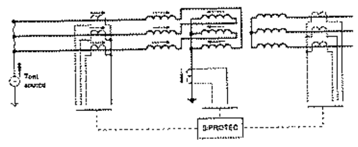

Figure 10-7 Residual-Current Measurement on a Zigzag Winding

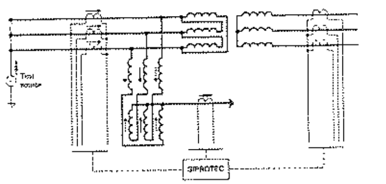

Figure 10-8 Residual-Current Measurement on a Delta Winding with Artificial Neutral Point in the Protection Range

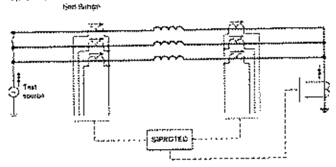

Figure 10-9 Residual-Current Measurement on a Grounded Longitudinal Reactance (Reactor, Generator, Motor)

Performance of Residual-Current Tests

For the commissioning tests, a residual current at a level of at least 2 % of the device's rated current per phase is required, for example, the test current must be at least 6 %.

> **NOTE**
> The following tests cannot replace a visual check of the correct current transformer connections. The completed checks are a prerequisite.

- Switch on the test current.
- Perform the circuit measurement with the test current switched on.
- Compare the currents displayed by the device under Measured values with those actually flowing:
  - All phase currents of the tested measuring point correspond to approx. 1/3 of the test current.
  - 3I0 of the tested measuring point corresponds to the test current.

- Phase currents and residual current on the untested measuring point are approx. 0 (no transformers).
- The current at the 1-phase current input – to the extent available in the measurement – corresponds to the test current.

Deviations can only occur with the 1-phase measuring input (if measured), since connection faults in the phase currents were already recognized in the symmetrical test.

In the case of deviations:

- Switch off the test source and the protected object. Ground the protected object or shut down the generator.
- Check the assignment of the additional measuring input currently being tested.
- Check the parameters for the compensation.
- Check and correct the connections and test setup.
- Repeat the measurements and check the amounts again.

Check Differential Protection

The tests described in the following encompass the current-differential protection, not the restricted ground-fault protection. The tests represented in the previous figures must have the following results. Ensure that the test current corresponds to 3I0.

- Residual current elimination

In the function group Transformer side, the neutral point is set as (parameter Neutral point = grounded) grounded, and in the function group Transformer there is the parameter Meas. gnd. current side 1 = no. The matrices are shown below.

$$\begin{pmatrix} I_{Diff,A} \\ I_{Diff,B} \\ I_{Diff,C} \end{pmatrix} = \left|\begin{pmatrix} I_{A,S1} \\ I_{B,S1} \\ I_{C,S1} \end{pmatrix} + \begin{pmatrix} I_{A,S2} \\ I_{B,S2} \\ I_{C,S2} \end{pmatrix}\right| = \frac{1}{3}\begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix}\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} I_{rest,A} \\ I_{rest,B} \\ I_{rest,C} \end{pmatrix} = \left|\begin{pmatrix} I_{A,max} \\ I_{B,max} \\ I_{C,max} \end{pmatrix}\right| = \frac{1}{3}\begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix}\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

- Residual current correction

In the function group Transformer side, the neutral point is set as (parameter Neutral point = grounded) grounded, and in the function group Transformer, there is the parameter Meas. gnd. current side 1 = yes. The differential and restraint currents measured result from the one-sided test to 0. In the following, the matrices are represented. I_Y is the measured residual current through the current transformer in the neutral point:

$$\begin{pmatrix} I_{Diff,A} \\ I_{Diff,B} \\ I_{Diff,C} \end{pmatrix} = \left|\begin{pmatrix} I_{A,S1} \\ I_{B,S1} \\ I_{C,S1} \end{pmatrix} + \begin{pmatrix} I_{A,S2} \\ I_{B,S2} \\ I_{C,S2} \end{pmatrix}\right| = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3}\begin{pmatrix} I_{Gnd} \\ I_{Gnd} \\ I_{Gnd} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3}\begin{pmatrix} -3I_0 \\ -3I_0 \\ -3I_0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} I_{rest,A} \\ I_{rest,B} \\ I_{rest,C} \end{pmatrix} = \left|\begin{pmatrix} I_{A,max} \\ I_{B,max} \\ I_{C,max} \end{pmatrix}\right| = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3}\begin{pmatrix} I_{Gnd} \\ I_{Gnd} \\ I_{Gnd} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

If there is a polarity reversal on the current transformer at the neutral point, a value that corresponds to 2/3 of the test current (3I0) results for the differential and restraint current per phase. The following matrices illustrate the situation.

$$\begin{pmatrix} I_{Diff,A} \\ I_{Diff,B} \\ I_{Diff,C} \end{pmatrix} = \left|\begin{pmatrix} I_{A,S1} \\ I_{B,S1} \\ I_{C,S1} \end{pmatrix} + \begin{pmatrix} I_{A,S2} \\ I_{B,S2} \\ I_{C,S2} \end{pmatrix}\right| = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3}\begin{pmatrix} I_{Gnd} \\ I_{Gnd} \\ I_{Gnd} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3}\begin{pmatrix} 3I_0 \\ 3I_0 \\ 3I_0 \end{pmatrix} = 2\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix}$$

$$\begin{pmatrix} I_{rest,A} \\ I_{rest,B} \\ I_{rest,C} \end{pmatrix} = \left|\begin{pmatrix} I_{A,max} \\ I_{B,max} \\ I_{C,max} \end{pmatrix}\right| = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix} + \frac{1}{3}\begin{pmatrix} I_{Gnd} \\ I_{Gnd} \\ I_{Gnd} \end{pmatrix} = 2\begin{pmatrix} I_0 \\ I_0 \\ I_0 \end{pmatrix}$$

10.4 Generator Differential Protection

10.4.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following 10.4.2 Primary Tests, because they cannot include connection faults. They are used to check the setting values, the proper function of the protection function, the engineering (for example, routing of the corresponding logical signals, display images with measured values, logic in the CFC, etc.) If you want to perform secondary tests, observe the following instructions.

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

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

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

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

> **NOTE**
> Tests of currents greater than 4 times the device rated current (or a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find further information in the Technical Data. Interrupt testing to allow cool-down!

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

If you are testing parameters set during operation, you must note that the setting value for the differential protection refers to the rated current of the protected object. The rated current is the primary current that results formally from:

$$I_{rated,Obj} = \frac{S_{rated,Obj}\,[\mathrm{MVA}] \cdot 1000}{\sqrt{3} \cdot V_{rated,Obj}\,[\mathrm{kV}]}\ [\mathrm{A}]$$

$S_{rated,Obj}$	Rated apparent power of the protected object
$V_{rated,Obj}$	Rated voltage of the protected object or the winding being observed

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

10.4.2 Primary Tests

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

To prevent overfunction on initial switch-on, for example due to the incorrect installation of a transformer, Siemens recommends switching the differential protection to test mode. The protection function operates, but does not issue a trip command. Check the differential and the restraint current with the protection malfunctional values in the fault log. The differential current must be 0 and the restraint current must correspond to the actually flowing generator current.

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

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

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10.5 Commissioning Notes Motor Differential Protection

10.5.1 Secondary Tests

Secondary tests can never replace the primary tests described in the following 10.5.2 Primary Tests, because they cannot include connection faults. They are used to control the setting values and the proper function of the protection function, engineering (for example, routing of the appropriate binary signals, display, enquiry with measured values, logics in the CFC, etc.). If you want to perform secondary tests, observe the following instructions.

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

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

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

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

> **NOTE**
>
> Tests of currents exceeding quadruple device rated current (or a maximum of 20 A) lead to an overload of the input circuits and may be performed only briefly. You can find further information in the Technical Data. Interrupt testing to allow cool-down!

The set pickup values refer to symmetrical 3-phase current in the case of 3-phase protected objects. If you are testing parameters set during operation, you must ensure that the setting value for the differential protection refers to the rated current of the protected object. The rated current is the primary current that results formally from

$$I_{\text{rated,obj}} = \frac{S_{\text{rated,obj}}\,[\text{MVA}] \cdot 1000}{\sqrt{3} \cdot V_{\text{rated,obj}}\,[\text{kV}]}\ [\text{A}]$$

$S_{\text{rated,obj}}$	Rated apparent power of the protected object
$V_{\text{rated,obj}}$	Rated voltage of the protected object or the winding being observed

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

10.5.2 Primary Tests

Remember primary testing is possible for motor protection applications. Starting tests on the motor with the system can be a possible cause of the fault. With the system at a standstill, you can apply a test current of approx. 10 % to 20 % of the rated current directly to the transformer terminals and connected transformer by means of a primary testing device. Simulate a load (through current). The differential current must be zero and the restraint current is the current which is fed in.

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

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

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

10.6 Functional Test of the Line Differential Protection

The line differential protection offers 2 types of tests:

- Test of the differential protection in a local device
- Test of the entire differential protection in all devices

You can test the Line differential protection function only locally on a device. You control the test mode with the controllable (_:2311:309) Test local device. If you select this operating mode, the Line differential protection becomes ineffective in all the other devices of the device combination. In the device to be tested locally, the Line differential protection remains effective. The locally installed and measured current is seen as differential current. Thereby, you can check the tripping behavior on the local device. Note, that the operate indications from the Line differential protection do not lead to the control of the circuit relay.

With the (_:2311:308) Test all devices test mode, you can check the Line differential protection function with all the devices of the device combination. You can check the reaction of the Line differential protection to parameter changes before actual operation. In the DIGSI 5, you can check the actual operating point in the differential protection characteristic curve (see Figure 10-16).

In both test modes, the device relays are not operated. If the device relays are to be operated, you must set this as follows in DIGSI or on the device:

- In DIGSI 5 under Settings → Device settings → Test support.
  Set a check mark for parameter (_:151) Oper. bin. outp. under test.
- On the device, under Settings → General → Test support → (_:151) Oper. bin. outp. under test.

For both test modes, all indications are marked with a test bit.

Test of the Differential Protection in a Local Device

You can switch the test of the local differential protection function on or off in the following ways:

- Via the operating dialog in DIGSI (online)
- Via the on-site operation panel
- Via the binary inputs >Test local device on and >Test local device off

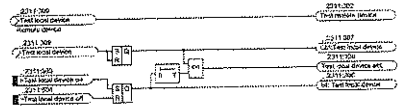

Figure 10-10 Logic Diagram for Testing the Local Device

The indications Ctrl:Test local device and BI: Test local device show in which way the test was switched on. If a device test was ordered by DIGSI or via the communication interface, then the indication (_:2311:307) Ctrl:Test local device is issued.

If the test is activated, the local differential protection function operates in test mode. This is signaled via the indications Test local device act. as well as Behavior (I-DIFF test) and Behavior (I-DIFF fast test). The differential protection functions in the other devices become inactive and report this state with the indications Inactive and Test remote device.

You can activate the operating mode manually in the following way:

- DIGSI: Online access → Interface → Device → Device information
- On-site operation panel: Main menu → Device functions → Line 1 → Line differential protection

With a test switch, you can activate the binary inputs and switch over the current inputs of the protection device to a current generator.

The following diagrams show potential variants on how to control binary inputs.

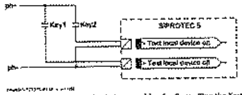

Figure 10-11 External Pushbutton Wiring for Controlling the Test of the Local Device

If a control switch is used, route the binary input >Test local device on as H (active with voltage) and the binary input >Test local device off as L (active without voltage).

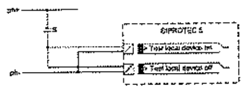

Figure 10-12 External Switch Wiring for Controlling the Test of the Local Device

Test of the Entire Differential Protection in All Devices

You can switch the test of the entire differential protection function in all devices on or off in the following ways:

- Via the operating dialog in DIGSI (online)
- Via the on-site operation panel
- Via the binary inputs >Test all devices on and >Test all devices off

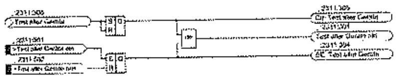

Figure 10-13 Logic Diagram for the Test of All Devices

The indications Ctrl: Test all devices and BI: Test all devices show in which way the test was started. If the test is activated, the differential protection function in all devices operates in test mode. This is signaled via the indications Test all devices act. and Behavior (I-DIFF test) and Behavior (I-DIFF fast test). In this state, the differential protection may be tested.

> **NOTE**
>
> The test of all devices cannot be set and will be rejected if the local differential protection functions are already logged off.

You can activate the operating mode manually in the following way:

- DIGSI: Online access → Interface → Device → Device Information
- On-site operation panel: Main menu → Device functions → Line 1 → Line differential protection

The following diagrams show possible variants of activation of the test operation type through control of binary inputs.

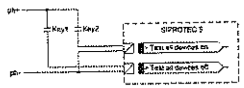

Figure 10-14 External Push-button Wiring for Controlling the Test of All Devices

If a control switch is used, route the binary input >Test all devices on as H (active with voltage) and the binary input >Test all devices off as L (active without voltage).

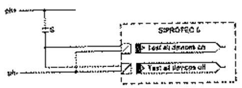

Figure 10-15 External Switch Wiring for Controlling the Test of All Devices

Checking the Differential and Restraint Current

You can check the differential and restraint current directly on the device or by means of DIGSI 5.

In order to find the differential and restraint current on the device, go to Operational measured values → Measurements → Line 1 → Functional measured values → Differential protection.

When using the DIGSI 5 to check the differential and restraint current, the connection with the device must be established first. To find the operational measured values of the line differential protection, go to Name of device → Measurements → Line 1. While in the working area, the operational measured values of the function can be found under Functional measured values → Aligning differential protection.

In DIGSI 5 the operating point (OP) derived from the differential and restraint current can also be checked in the graphic display of the differential protection characteristic curve. In order to find the differential protection characteristic curve in DIGSI 5, go to the project tree Online device (Name of device) → Test Suite → Protection functions → Line 1 → Line differential protection. The operating points derived from the differential current and the restraint current are graphically displayed in the differential protection characteristic curve (see the following figure).

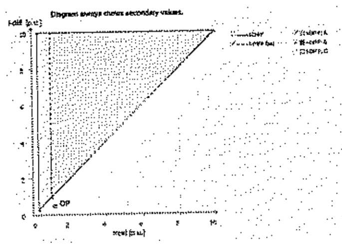

Figure 10-16 Characteristic Curve of the Differential Protection

To ensure reliable operation of the line differential protection, the operating point must be located inside the working area and clearly below the tripping lines.

If the differential current monitoring function is pickup or the operating point lies within the tripping area, proceed as follows:

- Check the pickup value for stage I-DIFF.
- Check the polarity of the current transformer.
- Verify that the differential current is generated by the primary system. Did you consider the charging current? It will be displayed as a permanent differential current.
  If these were not the causes of the differential current, the differential current can be generated by asynchronous communication networks. Such asynchronicity can be created by rerouting larger communication networks.
  Another cause of the differential current could be unbalances in the runtimes for the protection communication that have always existed but not been noticed. This means that the transmission times for the protection data back and forth are different, as a result of which the measured values received cannot be synchronized perfectly. Hence, a differential current that might activate the operate function during increased current flow will be calculated.

10.7 Logging Off the Local Line Differential Protection

For some applications it may be necessary to remove and log off the line differential protection from the total topology of the line differential protection. These applications include, for example:

- Maintenance work
- System expansion
- Testing the local line differential protection

EXAMPLE:

The following line formation is protected by the line differential protection with 3 devices.

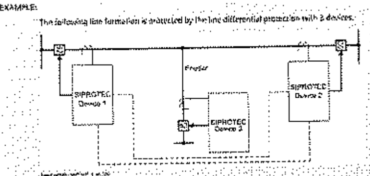

Figure 10-17 Differential Protection with 3 Devices for a Line with a Feeder

In the example, the feeder is to be decommissioned for maintenance or modification work. Device 3 should therefore also be switched off. Without additional measures, the line differential protection will no longer function and will send an indication that it is ineffective.

For this use case, the Line differential protection function must be logged off in device 3. The Line differential protection in device 3 can only be logged off if no current is flowing through the feeder. During the log-off process, device 3 checks whether the circuit breaker 3 is really open. If the Line differential protection is logged off in device 3, this is saved in the remaining devices 1 and 2 and Kirchhoff's current law will then be executed only with the currents of the devices 1 and 2.

If device 3 is successfully logged off, you can switch it off. The logoff of device 3 is saved in the remaining devices after it is switched off. If you switch device 3 back on, register it in the device combination again.

> **NOTE**
>
> Before logging off, you must switch off the feeder protected by the local line differential protection.

Logoff Options of the Line Differential Protection

You can log off the Line differential protection function as follows:

- Via the operating dialog in DIGSI or via the on-site operation panel
- Via communication through the controllable Function logoff (_:2311:339)
- Via the binary inputs, general: >Function logoff on (_:2311:507) or >Function logoff off (_:2311:508)

Conditions for Logging off the Function

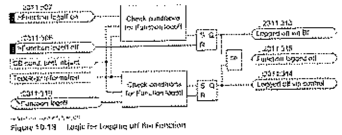

Figure 10-18 Logic for Logging off the Function

The following conditions must be fulfilled before the function is logged off:

- The current flow at the circuit breaker must be stopped. You must switch off the feeder protected by the local line differential protection.
  The locally recorded current of the logged off line end no longer flows into the sum of the currents. The function then only sums up the currents from the line ends that have not been logged off.
- The circuit-breaker position recognition in the Circuit-breaker function group (CB) provides the circuit-breaker condition via the internal signal CB state protected obj.
  If a protected object is supplied via 2 circuit breakers (CBs), for example, in case of a breaker-and-a-half layout, then the CB state of the protected object must be determined with both circuit breakers. In this case, the **Circuit-breaker condition for the protected object** function block performs the connection of the individual CB conditions.
  If one of the following 2 conditions is met, the CB status protected object internal signal is in the Open state:
  - All connected circuit breakers signal the Open state.
  - The >Disconnector open input is active.

  You can find more detailed information in chapter 5.3.4.6 Circuit-Breaker Condition for the Protected Object.
- Monitoring the communication topology in the device combination is only important if more than 2 devices are communicating via the protection interface. A function can only be logged off if this does not disturb the communication between the remaining devices in the device combination.

The logged-off local line differential protection can also be activated for test purposes (see 6.?.11 Functional Test of the Line Differential Protection). This has no influence or impact on the existing protection interface communication.

The following diagrams show potential variants on how to control binary inputs. If you would like to use push buttons, switch on these push-buttons as shown in the following figure. With the push-button **Key2**, you log off the function using: with the push-button **Key1**, you log the function on again.

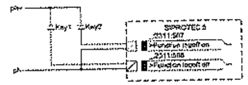

Figure 10-19 External Push-Button Wiring for Logging off the Local Line Differential Protection

If a control switch is employed, route the binary input >Function logoff on to H (active with voltage) and the binary input >Function logoff off to L (active without voltage). If the switch S is closed, the function is logged off.

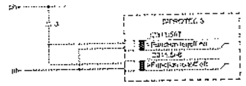

Figure 10-20 External Switch Wiring for Logging off the Local Line Differential Protection

Indications

The logged-off function reports the status (Function logged off) and the cause of the logoff.

If you have logged off the function via binary inputs, the indication Logged off via BI is issued.

If you have logged off the function via on-site operation, DIGSI 5, or the protection interface, the indication Logged off via control is issued.

10.8 Commissioning Notes Restricted Ground-Fault Protection

In addition to the protection setting and the correct routing of the signals, proper system integration is important. When checking the system integration, Siemens recommends the following procedure:

- **Polarity test of the current transformers** and assurance that the positive definition (to the protected object) is maintained. With a 3-phase connection, the current-transformer neutral point points to the protected object. For the current transformer at the neutral point, it is important that the side of the current transformer that is connected to terminal I2 is in the direction of ground (see Figure 10-21).
- **Checking the pickup value** can be performed by feeding in a neutral-point current.
- **Checking stability with an external fault** is possible by feeding in a current, if no bushing-type transformers are present on the transformer. The Figure 10-21 shows test proposal. A trip may not occur.

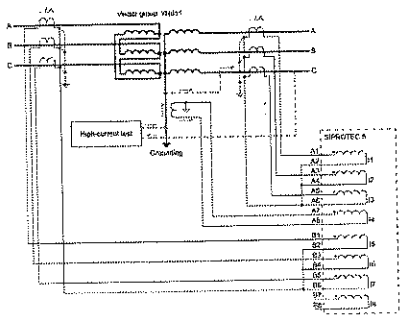

Figure 10-21 Test with High-Current Test Equipment

If a generator step-up transformer is protected, the generator can be used as test source. During a shutdown, an external 1-phase short circuit is built in. After this, the generator is excited and a minimum current is supplied. This minimum current lies under the permissible negative-sequence current. Set the restricted ground-fault protection to the lowest setting value. If the test current must be greater due to system conditions, the test takes place briefly (only a few seconds). Reestablish the original state after the test (primary plant, protection setting).

With smaller primary transformer rated currents, the test can take place by means of external supply (400 V method). Set the protection to the minimum threshold value.

10.9 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 or the protected object. For this, the line or the protected object must be switched on. A load current of at least 0.1 I_{rated} has to flow over the line or the protected object; 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 separated. The line or the protected object remains switched on 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 or the protected object.

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 undervoltage side of a transformer. The current-transformer neutral point then points in the direction of the protected object (for example transformer).

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

As a final step, switch off the system.

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

10.10.1 Overview

If the CT and VT connections are in the way that the ground quantities (3I0 and V0) are calculated by the device from the phase quantities, then, no additional directional test is required. Testing according to 10.9 Direction Test of the Phase Quantities (Current and Voltage Connection) is sufficient.

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

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

10.10.2 Directional Testing for Solid or Resistive-Grounded Systems

Primary Test

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

To generate a zero-sequence voltage V0, the e-n winding of one phase in the voltage-transformer set (for example, phase A) is bypassed, see Figure 10-22. If no connection on the e-n windings of the voltage transformer is provided, the corresponding phase is disconnected on the secondary side, see Figure 10-23. Only the current of the transformer in the phase of which the voltage is missing is transferred via the current circuit. If the line carries resistive-inductive load, the protection is subject to the same conditions as existing during a ground fault in line direction.

For directional testing, the **Directional ground-fault protection** function (67N) is configured and at least one stage is switched on. The pickup threshold of the stage must be below the load current of the line. If not, the binary input signal (_:12421:501) >Test of direction can be activated to lower the threshold temporarily for testing means without changing the respective parameters.

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

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

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

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

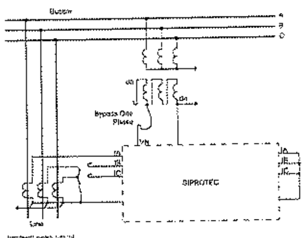

Figure 10-22 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Broken-Delta Connection

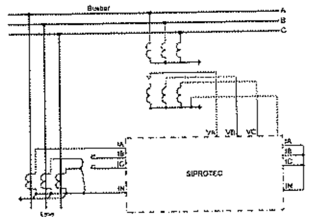

Figure 10-23 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Star Connection

10.10.3 Directional Testing for Isolated or Resonant-Grounded Systems

Primary Test

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

For directional testing, the Directional sensitive ground-fault detection function (67Ns) is configured and a directional stage is switched on. For example, the directional 3I0> stage with cos φ or sin φ measurement.

The most reliable test is the one with a primary ground fault. Proceed as follows:

- Isolate the line and ground it on both sides; on the farthest line end it must remain open during the entire test.
- Place a 1-phase ground-fault bridge on the line. For overhead lines, this can be done at an arbitrary location, in any case behind the current transformer (as seen from the busbar of the feeder to be tested). For cables, the grounding is done on the farthest end (sealing end).
- Remove the protective grounding from the line.
- Switch on the circuit breaker on the line to be tested.
- Check direction indication (LED if routed).
- Check the indication (_:2023) Ground fault in the ground-fault log or fault log with regard to its direction. The indication (_:2023) Ground fault forward must be logged as direction information. If backwards is determined as the direction, either with the current connections or the voltage connections, there is an inversion in the neutral path. For the display unknown, the ground current is probably too low.
- Switch the line off and ground it.

This completes the test.

10.11 Functional Test Protection Communication

10.11.1 Checking the Protection-Data Communication

Checking the Protection-Data Communication

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

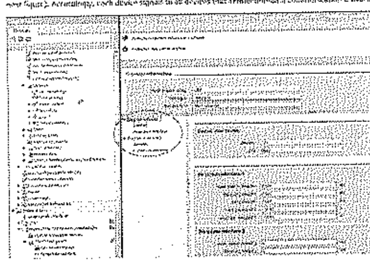

Figure 10-24 Connection Establishment in DIGSI 5

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

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

If a connection is successfully established, the field Status of topo recog. shows the indication [illegible] DIGSI 5 (see Figure 10-24).

If 2 devices are parameterized incorrectly, the Status of topo recog. field shows the indication [illegible] (see Figure 10-24).

In Figure 10-25 there is no protection data communication between device 1 and device 2, that is, the protection interfaces 1 and 2 of device 1 do not receive data. The transmission of protection data is interrupted and differential protection is ineffective. One reason for this can be a remote control with DIGSI via the protection interface. In this case, the protection connection is interrupted and the connection is used exclusively for DIGSI.

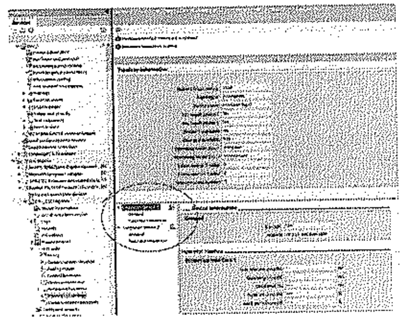

Figure 10-25 Protection-Data Communication Deactivated

10.11.2 Directional Test

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

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

10.12 Functional Test for Overexcitation Protection

Secondary Test

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

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

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

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

Example

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

It follows from the above that k = 1.1. For example, when verifying the nominal conditions if the secondary rated voltage is 100 V, a voltage of 1.1 * 100 V = 110 V must be supplied. The measured value of the function Measured value V/f must display 1.0050.

> **NOTE**
> When checking the dependent stage, ensure it is associated with a thermal replica. When repeating a test, always reset the replica, using the binary input indication >Reset therm. replica [illegible]

Primary Test

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

Instantaneous overexcitation is a result of the following function:

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

where:

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

10.13 Functional Test of Thermal Overload Protection

Secondary Test

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

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

Test without Previous Load

- Test the operate time at 1.5 $I_{\theta,rated,obj}$.
  In the example, the following power-system data are assumed:
  $I_{rated,obj} = 483\ A$
  $I_{rated,prim,CT} = 750\ A$
  $I_{rated,sec,CT} = 1\ A$

The primary test current is 1.5 * 483 A = 724.5 A. This results in a secondary current of 724.5 A * 1A/750A = 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 $I_{previous\ load} = 0$. The setting parameters reveal the K-factor (for example, 1.1) and the Thermal time constant (for example, 600 s or 10 min).
- Test from the cold state.

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

- 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 ($I_{previous\ load} = I_{rated,obj}$) 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 $I_{\theta,rated,obj}$), the overload protection will trip at the following time.

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

875

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.

10.14 Functional Test Hotspot Calculation

10.14.1 Secondary Test

NOTE

For the secondary test of the Hotspot calculation function, note that all setting parameters refer to the primary variables of the protected object. The protection device considers the current transformer ratio from the power-system data and adapts the data to the device-rated variables. Take this behavior 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 you change the settings of the function or switch it off, the thermal image is also reset.
- Check the calculated hotspot temperature at a load current of 1.5 · $I_{rated,obj}$.

Once the oil or sure time constant has expired, the hotspot temperature comes from the measured oil temperature and the temperature difference between the hotspot and the top oil temperature.

Example

If the measured oil temperature is a uniform 70 °C, a temperature differential results between the hotspot and the top oil temperature of:

IEC 60076-7

$\Delta\theta_{h,0}(t)$	$= k^y H_{gr}$
Y	= 1.6
H_{gr}	= 23
K	= 1.6

IEEE C57.91 2011

$\Delta\theta_{h,U}(t)$	$= k^{2m} H_{gr}$
m	= 0.8
H_{gr}	= 22
K	= 1.5

In steady state, the hotspot temperature settles to $\theta_h(t)$ = 114 °C.

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 test.

10.15 Reverse Power Protection

10.15.1 Secondary Test

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

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

10.15.2 Primary Test

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

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

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

Use the functional measured values P1 avg and Q1 avg (type averaged)

Table 10-3 Value Table for Angle Correction

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

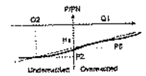

Figure 10-26 Determining the Correction Angle φ_{corr}

CAUTION

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

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

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

CAUTION

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

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

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

- Regulate the driving power to 0 by closing the control valves. The generator draws its reverse power from the electrical power system.
- Change the excitation until the reactive power Q ≈ 0. As a control measurement, read the active power P_0 and the reactive power Q_0 with the sign, and enter the values in Table 10-3.
- Increase the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (overexcited).
  Read the reverse power P_1 with the sign (negative) and the reactive power Q_1 with the sign (positive) in the functional measured values and note these 2 values in the values table.
- Reduce the excitation slowly until reaching approx. 30 % of the rated apparent power of the generator (underexcited).
  Read the reverse power P_2 with the sign (negative) and the reactive power Q_2 with the sign (negative) in the functional measured values and note these 2 values in the values table.
- Run the generator again at no-load excitation and select the desired operating state.
- With the measured value pairs (P_1, Q_1 and P_2, Q_2), calculate the correction angle φ_{corr} with the following formula:

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

NOTE

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

- Enter this angle φ_{corr} with the same sign as the new correction angle (parameter _:2311:103) Angle correction):

Setting value _:2311:103) Angle correction = φ_{corr}

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

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

Set the value as pickup value: Parameter (_:991:3) Threshold = Ppickup

Check of the Reverse-Power Protection

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

- In both cases, check the consumed active power (reverse power). The valves could be leaking.
- Repeat the reverse-power measurement to confirm that the settings are correct.
- To check the efficiency of the reverse power protection on the basis of the indications, use the parameter (_:991:1) Mode to switch the reverse power protection to test .
  Proceed as follows:

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

NOTE

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

- Close the quick-stop valve.
- From the functional measured value P1avg , take the reverse power that was measured by the protection device as the active power.
- If – contrary to expectations – this value is smaller than the reverse power when the control valves are closed, take 50 % of this value as the setting value for the reverse-power protection.
- Shut down the machine by activating the reverse-power protection. Set the parameter (_:991:1) Mode to on .

10.16 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 measures 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 activated
- Binary input signal supervision (in the case of an external start) is enabled and blocks the function.
- All indications generated are generated without test bit.

Circuit-Breaker Auxiliary Contacts

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

- Make sure that the correct assignment has been checked.

Internal Starting Conditions (Trip Command from Internal Protection Function)

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

- Check the settings for circuit-breaker failure protection. See also chapter 6.48.4 Application and Setting Notes.
- For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by a device-internal test sequence (see description in the Operating manual). It can also be a secondary test current.
- Generate the trip for the protection function. This can be generated within the device by a test sequence (see description in the Operating manual) or by creating corresponding secondary test values.
- The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

External Starting Conditions (Trip Command from External Protection Function)

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

- Check the settings for circuit-breaker failure protection.
  See also chapter 6.48.4 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 start and – in case of 2-channel operation – also the dynamic supervision of the binary input signals. For this purpose, induce pickup of the supervision and check the supervision indications and the ready signal in the event log buffer.

Start by Trip Command from the External Protection without Current Flow

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

Repetition of the Local Tripping (T1)

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

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

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

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

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

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

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

- It is practical to test the communication channel for the remote trip while transmitting other signals in accordance with 10.11.1 Checking the Protection Data Communication.

Termination

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

10.17 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 activated to closed.

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

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

Structure of the Function

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

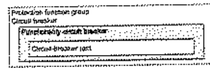

Figure 10-27 Embedding of the Function

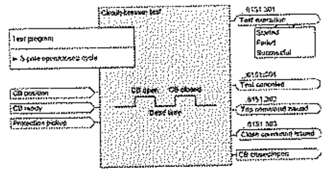

Figure 10-28 Structure of the Function

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-close-open cycle (indication >Ready).
- A protection function must not have been picked up in the circuit-breaker protection function group responsible for the circuit breaker.

Figure 10-29 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 + Output time + 5 s), the circuit-breaker test is canceled 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 (_:6151:102) 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.

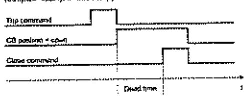

Figure 10-29 Progress over Time of a Circuit-Breaker Test Cycle

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

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

NOTE

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

You can start the test program as follows:

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

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

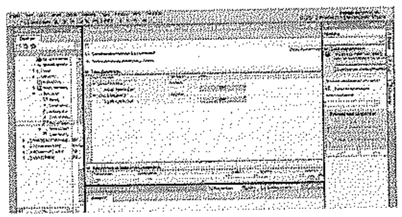

Figure 10-30 Circuit-Breaker Test in the Test Suite in DIGSI

- 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.

10.18 Functional Test of the Inrush-Current Detection

General

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

Harmonic Analysis

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

The inrush-current detection creates a blocking signal.

CWA Process

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

The inrush-current detection creates a blocking signal.

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10.19 Functional Test of Transient Ground-Fault Protection

General

This function requires the correct polarity of the ground current 3I0 and the neutral-point displacement voltage VN respectively the zero-sequence voltage V0. For the directional test of these quantities, refer to chapter 10.10 Direction Test of Ground Quantities for Directional Ground-Fault Detection.

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

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

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

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

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

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

Secondary Test

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

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

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

Example

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

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

10.20 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.

10.21 Functional Test for the Phase-Rotation Reversal

- Check the phase-sequence direction at 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.

10.22 Primary and Secondary Testing of the Synchronization Function

Measuring the Circuit-Breaker Closing Time

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

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

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

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

Siemens recommends the following procedure:

- Establish a condition in which the circuit breaker can be closed without hazard.
- If V2 switching through, activate the operating mode Close cmd. at V1< & V2> for the synchronization stage by setting it 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 for the fault recorder. With the release of closure, a fault record of the parameterized duration is set up (the default setting of 500 ms is more than adequate for this).
- Starting the synchronization stage. The device activates immediately.
- Read the fault record and determine the closing time via SIGRA (see Figure 10-31). Use the 2 cursors and the time-measuring function for this. Position the first cursor on the closing close command. The occurrence of the second voltage signals the closed power-switching poles. Place the second cursor on the arising 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.

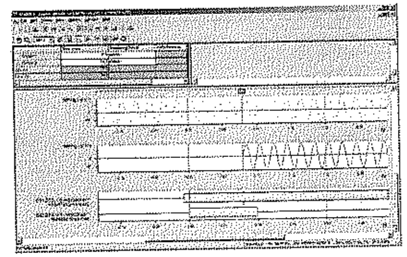

Figure 10-31 Measurement of the Circuit-Breaker Closing Time

2. The arrangement in Figure 10-32 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.

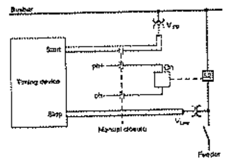

Figure 10-32 Measurement of the Circuit-Breaker Closing Time

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.

Requirements:

- You have checked the setting values again.
- The circuit breaker is switched off. The close command for the circuit breaker is interrupted [illegible] the close commands. 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 of synchronization, that is, at 12 hours. The time from until the close command then corresponds to a cycle with the maximum 180°. At a frequency difference of 0.1 Hz, the duration is thus 10 s.
- Insofar as permissible, perform this attempt several times for overasynchronous switching and near synchronous switching.
- The switching performance can be checked with an external recorder or the integrated fault recorder 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 connection with the manual synchronization, check the proper release for closure.
- Synchronize the generator manually. Start the synchronization stage externally via a binary input. Check the proper release for closure with the indication log or via the fault record. You have to start the fault recording explicitly.

11 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 of the modular devices	Measuring range of the non-modular devices
	5 A 1 A	0 A to 500 A 0 A to 100 A	0 A to 250 A 0 A to 50 A
Instrument transformers	5 A 1 A	0 A to 8 A 0 A to 1.6 A	0 A to 8 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 transducers	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 MT3 terminal point E9)
Measurement repetition	62.5 μs

Table 11-2 High-Speed Measuring-Transducer Inputs, Current

Differential current input channels	8 [4]

[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.

Measuring range	DC 20 mA to +20 mA
Fault	< 0.5 % of the measuring range
Input impedance, current	22 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	33 VA	24 VA
1/6 expansion module	3 W	6 VA	6 VA
1/6 plug-in module assembly without plug-in modules (modules CB202)	3.5 W	14 VA	7 VA
Plug-in module for base module or plug-in module assembly (for example, communication module)	< 5 W	< 6 VA	< 6 VA
Stored-energy time for auxiliary voltage outage or short circuit, modular devices		For V ≥ DC 24 V ≥ 50 ms For V ≥ DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 50 ms	
Stored-energy time for auxiliary voltage outage or short circuit, non-modular devices		For V ≥ DC 24 V ≥ 20 ms For V ≥ DC 60 V/DC 110 V ≥ 50 ms For V ≥ AC 115 V ≥ 200 ms	

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 2.8 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

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 Maximum: ≤ 9 ms
Rated data of the output contacts in accordance with UL certification	B150 Q300

Power Relay (for Direct Control of Motor Switches)

Switching capacity for permanent and periodic operation		
250 V/4.0 A 220 V/4.5 A 110 V/5.0 A 60 V/5.0 A 48 V/5.0 A 24 V/5.0 A	1000 W 1000 W 550 W 300 W 240 W 120 W	In order to prevent any damage, the external protection circuit must switch off the motor in case the motor is blocked.
Here on switching power for 30 s, recovery time until switching on again is 15 minutes. For short-term switching operations, an impulse/pause ratio of 3 % must be considered.		
110 V/9.0 A 60 V/10.0 A 48 V/10.0 A 24 V/10.0 A	1000 W 600 W 480 W 240 W	Continuous and inching operation is not permitted. In order to prevent any damage, the external protection circuit must switch off the motor in case the rotor is blocked.
AC and DC contact voltage		250 V
Permissible continuous current per contact		5 A
Permissible current per contact (switching on and holding)		30 A for 1 s
Short-time current across closed contact		250 A for 30 ms
Total permissible current for contacts connected to common potential		5 A
Switching time OOT (Output Operating Time) Additional delay of the output medium used		≤ 16 ms
Rated data of the output contacts in accordance with UL certification		DC 300 V, 30 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	8.7 kg	12.3 kg	15.9 kg	19.5 kg

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

	Device Size Weight of the Non-Modular Devices 7xx82
Type of construction	1/3
Flush-mounting device	3.7 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 [6] (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)

[6] 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 [8] (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 [9] (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) IP2x 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)

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

UL Note

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

Tightening Torques for Terminal Screws

Type of Line	Current Terminal	Voltage Terminal with Spring-Loaded Terminals	Voltage Terminal with Screw Connection
Litz wire with ring-type lug	1.7 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 Transformer Differential Protection

Setting Values

Operate Curve			
Threshold value	I-DIFF>	0.05 to 2.00	Increments of 0.01
Slope 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Islop	IS-SLOPE	0.00 to 5.00	Increments of 0.01
Slope 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Islop	IS-SLOPE	1.00 to 20.00	Increments of 0.01
Startup detection			
Startup detection threshold value	IS-START	0.1 to 2.0	Increments of 0.1
Characteristic curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum starting time		0.1 s to 180.0 s	Increments of 0.1 s
DC-Component detection			
Characteristic curve increase factor DC		1.0 to 5.0	Increments of 0.1
Inrush-current detection			
Component of 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of crossblk. 2nd har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
Blocking of overexcitation			
Component of 3rd harmonic		10 % to 80 %	Increments of 1 %
Duration of crossblk. 3rd har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
Component of 5th harmonic		10 % to 80 %	Increments of 1 %
Duration of crossblk. 5th har.		0.00 s to 200.00 s or ∞	Increments of 0.01 s
Idiff limit 3rd, 5th harm.	IDIFF-MAX	0.5 to 20.0	Increments of 0.1
Recognition of external faults			
Additional stabilization threshold value	IS-EXTFLT	1.00 to 20.00	Increments of 0.01
Additional stabilization duration		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Crossblk. duration additional stabilization		0.00 s to 2.00 s or ∞	Increments of 0.01 s
Operate curve		See Figure 11-1	

Functional Measured Values

Measured Value	Description
_:2311:300 A, B, C	Differential current
_:2311:301 A, B, C	Restraint current

Idiff Fast

Threshold value	I-DIFF>>	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Response Tolerance

For preset characteristic curve parameters; for 2 sides with one measuring point each	
Idiff stage and characteristic curve	2 % of the setting value

Idiff fast stage	3 % of the setting value

Time Delays

Idiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Idiff fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

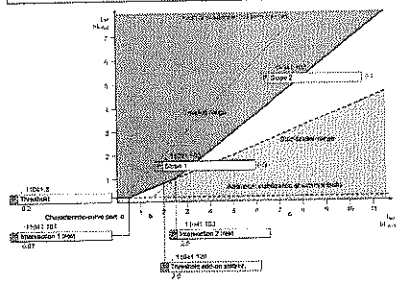

Figure 11-1 Operate Curve of the Differential Protection

Operating Times

Operate times for one-sided supply		
Idiff stage, min	50 Hz	23 ms + OOT[3]
	60 Hz	20 ms + OOT
Idiff fast stage, min	50 Hz	9 ms + OOT
	60 Hz	8 ms + OOT
Dropout time, approx.	50 Hz	29 ms
	60 Hz	26 ms
Dropout ratio	Approx. 0.7	

Adaptation for Transformers

Vector group adaptation	0 to 11 (x 30°)	Increments of 1
Neutral-point treatment	Grounded or not grounded (for each winding)	

[3] Refer to protection functions, for example overcurrent protection

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

Frequency tracking	10 Hz to 80 Hz

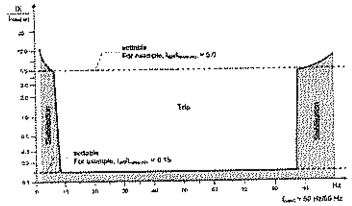

Figure 11-2 Frequency Influence when Using Transformer Differential Protection

11.3 Restricted Ground-Fault Protection

Setting Values

Threshold value[4]	0.05 A to 2.00 A	Increments of 0.01 A
Gradient	0.00 to 0.95	Increments of 0.01
Operate curve	See figure	
Pickup tolerance (for preset characteristic curve parameters; for 2 sides with 1 measuring point each)	2 %	
Tripping delay	0.00 s to 60.00 s or ∞ (no tripping)	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion
(_:307) : Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion
(_:311) I REF,Trip operate	Operate quantity of the restricted ground-fault protection when OFF
(_:312) I Angle,REF operate	Stabilizing value of the restricted ground-fault protection when OFF
(_:301) I diff.	Differential current
(_:302) I restr.	Restraint current

Dropout Ratio

Threshold value	0.7

Dropout

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

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

Times

7UT82/7UT85/7UT86/7UT87		
Frequency	50 Hz	60 Hz
	Operate time	Operate time

[4] The specified setting limits may be only restricted further limited, depending on the transformer adaptation factor. (For this refer to Chapter 6.4.1 Application and Setting Notes)

At 1.5 · setting value threshold value At 2.5 · setting value threshold value	33 ms + OOT 27 ms + OOT	32 ms + OOT 26 ms + OOT
Dropout time approx.	60 ms	67 ms

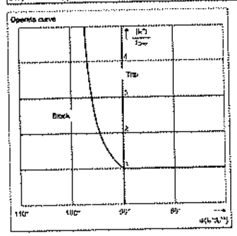

Figure 11-4 Restricted Ground-Fault Protection Operate Curve depending on the Phase Angle between I_0* and I_0** at $|I_0^*| = |I_0^{**}|$ (180° = External fault)

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11.4 Motor Differential Protection

Setting Values

Operate curve			
Threshold value	I/I_{rated}	0.05 to 2.00	Increments of 0.01
Slope 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Istab	I/I_{rated}	0.00 to 5.00	Increments of 0.01
Slope 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Istab	I/I_{rated}	1.00 to 20.00	Increments of 0.01
Startup detection			
Startup detection threshold value	I/I_{rated}	0.1 to 2.0	Increments of 0.1
Characteristic curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum starting time		0.1 s to 180.0 s	Increments of 0.1 s
DC-Component detection			
Characteristic curve increase factor DC		1.0 to 5.0	Increments of 0.1
Detection of external faults			
Additional stabilization threshold value	I/I_{rated}	1.00 to 20.00	Increments of 0.01
Additional stabilization duration		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Crossblk. duration additional stabilization		0.00 s to 2.00 s or ∞	Increments of 0.01 s
Operate curve		See figure	

Idiff Fast

Threshold value	I/I_{rated}	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Response Tolerance

For preset characteristic curve parameters; for 2 sides with one measuring point each	
Idiff stage and characteristic curve	2 % of the setting value
Idiff fast stage	2 % of the setting value

Time Delays

Idiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Idiff fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

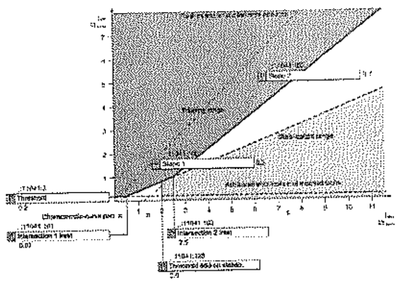

Figure 11-4 Operate Curve of the Differential Protection

Operating Times

Operate times for one-sided supply		
Stage I_{diff}>, min	50 Hz 60 Hz	23 ms + OOT[3] 20 ms + OOT[3]
Stage $I_{diff\ fast}$>, min	50 Hz 60 Hz	8 ms + OOT[3] 8 ms + OOT[3]
Dropout time, approx.	50 Hz 60 Hz	29 ms + OOT 26 ms + OOT
Dropout ratio	Approx. 0.7	

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

Frequency tracking	10 Hz to 80 Hz

[3] Refer to protection functions, for example overcurrent protection

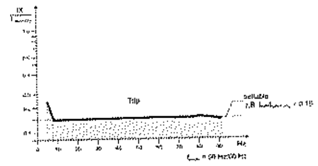

Figure 11-5 Frequency Influence when Using Motor Differential Protection

11.5 Generator Differential Protection

Setting Values

Operate Curve			
Threshold value	I/I_{rated}	0.05 to 2.00	Increments of 0.01
Slope 1		0.00 to 0.80	Increments of 0.01
Intersection 1 Istab	I/I_{rated}	0.00 to 5.00	Increments of 0.01
Slope 2		0.25 to 0.95	Increments of 0.01
Intersection 2 Istab	I/I_{rated}	1.00 to 20.00	Increments of 0.01
Startup detection			
Startup detection threshold value	I/I_{rated}	0.1 to 2.0	Increments of 0.1
Characteristic-curve increase factor		1.0 to 5.0	Increments of 0.1
Maximum starting time		0.1 s to 180.0 s	Increments of 0.1 s
DC-component detection			
Characteristic-curve increase factor DC		1.0 to 5.0	Increments of 0.1
Detection of external faults			
Additional stabilization threshold value	I/I_{rated}	1.00 to 20.00	Increments of 0.01
Additional stabilization duration		0.00 s to 5.00 s or ∞	Increments of 0.01 s
Crossblk. duration additional stabilization		0.00 s to 2.00 s or ∞	Increments of 0.01 s
Operate curve		see diagram Figure 11-6	

Idiff Fast

Threshold value	I/I_{rated}	0.5 to 35.0	Increments of 0.1
Tripping delay		0.00 s to 60.00 s	Increments of 0.01 s

Response Tolerance

For preset characteristic curve parameters; for 2 sides with one measuring point each	
Idiff stage and characteristic curve	2 % of the setting value
Idiff fast stage	2 % of the setting value

Time Delays

Idiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Idiff fast stage	0.00 s to 60.00 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

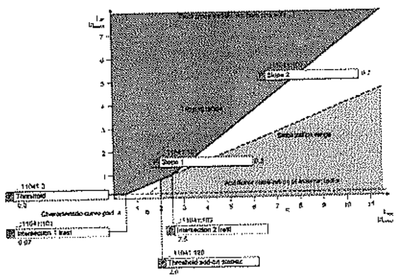

Figure 11-6 Operate Curve of the Differential Protection

Operating Times

Operate times for one-sided supply		
Stage I_{diff}>, min	50 Hz 60 Hz	23 ms + OOT[4] 20 ms + OOT
Stage $I_{diff\ fast}$>, min	50 Hz 60 Hz	8 ms + OOT 8 ms + OOT
Dropout time, approx.	50 Hz 60 Hz	29 ms + OOT 26 ms + OOT
Dropout ratio	Approx. 0.7	

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

Frequency tracking	10 Hz to 80 Hz

[4] Refer to protection functions, for example overcurrent protection

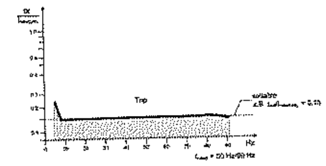

Figure 11-7 Frequency Influence when Using Generator Differential Protection

11.6 Line Differential Protection

Tripping Thresholds, I-DIFF Stage

Threshold value	10.0 % to 2000.0 % of $I_{rated,operat.obj}$	Increments of 0.1 %
Threshold value upon switching	10.0 % to 2000.0 % of $I_{rated,operat.obj}$	Increments of 0.1 %

Measured Value of the I-DIFF Stage

In order to clarify failures, the I-DIFF stage provides the following measured values:

Measured Value	Description
_:34512:300 I diff.	Differential current
_:34512:301 I restr.	Restraint current (overall restraint)
_:34512:302 I local	Value of local current phasor
_:34512:308 I restr.L	Local restraint current
_:34512:309 I CTerr.	Partial component of the local restraint current that considers the transformer fault.
_:34512:310 I distort.	Subcomponent of the local restraint current that considers the fault caused by signal distortion. Each deviation of the signal from from the sinus shape is interpreted as a signal distortion. The deviation between the actual signal form and the sinus shape will be converted to a percentage of the stabilized one.
_:34512:322 I sync	Subcomponents of the overall restraint that are caused by faults during the time synchronization of the current phasor.

Tripping Thresholds, I-DIFF Stage Fast

Threshold value	80.0 % to 10 000.0 % of $I_{rated,operat.obj}$	Increments of 0.1 %
Threshold value upon switching	80.0 % to 10 000.0 % of $I_{rated,operat.obj}$	Increments of 0.1 %

Trigger Value Tolerances

When using up to 3 line ends	5 % of setting value or 1 % of I_{rated} for each line end
When using up to 6 line ends	10 % of setting value or 1 % of I_{rated} for each line end

Operating Times

The tripping times depend on the number of line ends, the communication speed, and the configured output contacts. The following data assume a transmission rate of at least 512 kbit/s.

Tripping Time of the I-DIFF Stage		
When using 2 line ends	Minimum (50 Hz/60 Hz)	26 ms/23 ms + OOT[4]
	Typical (50 Hz/60 Hz)	28 ms/25 ms + OOT
When using 3 line ends	Minimum (50 Hz/60 Hz)	26 ms/23 ms + OOT
	Typical (50 Hz/60 Hz)	30 ms/27 ms + OOT
When using 6 line ends	Minimum (50 Hz/60 Hz)	31 ms/27 ms + OOT
	Typical (50 Hz/60 Hz)	37 ms/34 ms + OOT
Dropout Times of the I-DIFF Stage		
For all line ends	Typical	34 ms to 49 ms + OOT

Tripping Time of the I-DIFF Fast Stage		
When using 2 line ends	Minimum	8 ms + OOT
	Typical	11 ms + OOT
When using 3 line ends	Minimum	8 ms + OOT
	Typical	11 ms + OOT
When using 6 line ends	Minimum	13 ms + OOT
	Typical	19 ms + OOT
Dropout Times of the I-DIFF Fast Stage		
For all line ends	Typical	34 ms to 49 ms + OOT

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

Time Delays

Delay of the I-DIFF stage	0.00 s to 60.00 s	Increments of 0.01 s
Delay of the I-DIFF fast stage	0.00 s	Not adjustable
Delay of 1-phase pickup in resonant-grounded/isolated systems	0.00 s to 0.50 s	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	

Self-Stabilization

Transformer Fault for Each Line End of the Protected Object		
Error transmission ratio	1.00 to 10.00	Increments of 0.01
Transformer error A	0.5 % to 50.0 %	Increments of 0.1 %
Transformer error B (class)	0.5 % to 50.0 %	Increments of 0.1 %
Other stabilizing values (adaptive self-stabilization)	Frequency deviations, runtime differences, harmonics, synchronism quality, jitter	

Adjustments for Transformers in the Protection Range

Vector group adjustment (V and I)	0 to 11	Increments of 1
Residual current elimination	Yes or no	

Adjustment of the Charging-Current Compensation

Additional rest. current in mult. of rated	1.0 to 4.0	Increments of 0.1
Total line length	0.1 km to 1000.0 km	Increments of 0.1 km

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	Operating range with rated accuracy
$0.8 \le f/f_{rated} < 0.9$ $1.1 < f/f_{rated} \le 1.2$	Normal operating range without rated accuracy
$0.0 \le f/f_{rated} < 0.8$	Stable operation without rated accuracy

11.7 Stub Differential Protection

Tripping Thresholds of the IDiff Stage

Threshold value	10.0 % to 2000.0 % of $I_{rated,operat.obj}$	Increments of 0.1 %

Tripping Thresholds of the IDiff Fast Stage

Threshold value	80.0 % to 10 000.0 % of $I_{rated,operat.obj}$	Increments of 0.1 %

Tolerances of the Tripping Thresholds

5 % of the setting value or 1 % of I_{rated}

Operating Times

The reported tripping times assume the issuance of commands via high-speed relays (type HS).

Tripping Times of the IDiff Stage	
Minimum (50 Hz/60 Hz)	26 ms/23 ms + OOT[5]
Typical (50 Hz/60 Hz)	28 ms/25 ms + OOT
Dropout Times of the IDiff Stage	
Typical	34 ms to 49 ms + OOT

Tripping Times of the IDiff Fast Stage	
Minimum	8 ms + OOT
Typical	11 ms + OOT
Dropout Times of the IDiff Fast Stage	
Typical	34 ms to 49 ms + OOT

Time Delays

Tripping delay of the IDiff stage	0.00 s to 60.00 s	Increments of 0.01 s
Tolerance	1 % of the setting value or 10 ms	

Self-Stabilization

Transformer Fault for Each Line End of the Protected Object		
Error transmission	1.00 to 10.00	Increments of 0.01
Transformer fault A	0.5 % to 50.0 %	Increments of 0.1 %
Transformer fault B (class)	0.5 % to 50.0 %	Increments of 0.1 %
Other stabilizing values (adaptive self-stabilization)	Frequency deviations, harmonic components	

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	Operating range with rated accuracy
$0.8 \le f/f_{rated} < 0.9$ $1.1 < f/f_{rated} \le 1.2$	Normal operating range without rated accuracy
$0.0 \le f/f_{rated} < 0.8$	Stable operation without rated accuracy

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

11.8 Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0>	For current transformer type protection and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type protection and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pulses until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 100.00 s	Increments of 0.01 s
Reset time			1.00 s to 600.00 s	Increments of 0.01 s
Number of pulses for operate			2 to 100	Increments of 1

Dropout

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

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

Times

Pickup time	Approx. 30 ms + OOT[6] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with less sensitivity

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

Tolerances

Currents	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A)
Times	1 % of the setting value or ± 10 ms

11.9 Non-Directional Intermittent Ground-Fault Protection

Setting Values

Threshold value 3I0> intermittent	For current transformer type protection and I_{rated} = 1 A		0.030 A to 35.000 A	Increments of 0.001 A
	For current transformer type protection and I_{rated} = 5 A		0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Number of pickups until intermittent ground fault			2 to 10	Increments of 1
Pickup extension time			0.00 s to 10.00 s	Increments of 0.01 s
Sum of extended pickup times			0.00 s to 100.00 s	Increments of 0.01 s
Reset time			1.00 s to 600.00 s	Increments of 0.01 s

Dropout

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

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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[7] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Active with less sensitivity

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

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Tolerances

Currents	3I0 via protection-class current transformers: 1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
	3I0 via sensitive current transformer: 1 % of setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A)
Times	1 % of the setting value or 10 ms

11.10 Sensitive Ground-Fault Detection

11.10.1 General

Setting Values

Delay pickup V0			0.00 s to 0.20 s	Increments of 0.01 s
Dropout delay			0.00 s to 60.00 s	Increments of 0.01 s
Core balance current transformer current 1 Core balance current transformer current 2	Protection-class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Core balance current transformer angle correction F1 Core balance current transformer angle correction F2			0.0° to 5.0°	Increments of 0.1°

Times

Pickup times	Approx. 25 ms + OOT[4] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Dropout times	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

0.9 ≤ 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 [5]
f < 10 Hz f > 80 Hz	Active with less sensitivity [6]

Tolerances

Currents	3I0 via sensitive current transformer: 1 % of the setting value or 0.1 mA (I_{rated} = 1.6 A) or 0.5 mA (I_{rated} = 8 A, f_{rated} ± 10 %)
	3I0 via protection-class current transformers: 1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A, f_{rated} ± 10 %)
Voltages	1 % of the setting value or 0.05 V
Times	1 % of the setting value or 10 ms

[4] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays
[5] Transient ground-fault stage is inactive
[6] Transient ground-fault stage is inactive

Direction determination angle error[7]	≤ 1° at 3I0 ≥ 5 mA, V0 = 0.6 V ≤ 2° at 3I0 < 5 mA, V0 = 0.6 V

11.10.2 Directional 3I0 Stage with Cos φ or Sin φ Measurement

Setting Values

Direction method of measurement			cos φ sin φ	-
Threshold value 3I0> Minimum directional 3I0> for direction determination	Protection-class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of the direction range α2 constraint of the direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

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

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[8] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[7] Not applicable to 11.10.4 Directional 3I0 Stage with φ(V0,3I0) Measurement
[8] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

11.10.3 Directional Transient Ground-Fault Stage

Setting Values

Threshold value 3I0>	Protection-class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.001 A to 1.600 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Maximum operational V0			0.300 V to 340.000 V	Increments of 0.001 V
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

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

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 135 ms + OOT[9] at 50 Hz Approx. 112 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT at 50 Hz Approx. 15 ms + OOT at 60 Hz

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

11.10.4 Directional 3I0 Stage with φ(V0,3I0) Measurement

Setting Values

Threshold value 3I0>	Protection-class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Min. V0> for direction determination			0.300 V to 200.000 V	Increments of 0.001 V
Time delay of the direction determination			0.00 s to 60.00 s	Increments of 0.01 s
Rotation angle of the reference voltage			-180° to 180°	Increments of 1°
Forward range +/-			0° to 180°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

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

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[10] at 50 Hz Approx. 21 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 21 ms + OOT at 50 Hz Approx. 20 ms + OOT at 60 Hz

Tolerances

Direction-calculation angle error	≤ 1° at 3I0 ≥ 10 mA, V0 = 0.6 V ≤ 2° at 2 mA ≤ 3I0 ≤ 10 mA, V0 = 0.6 V ≤ 3° at 3I0 ≤ 2 mA, V0 = 0.6 V

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

11.10.5 Directional Y0 Stage with G0 or B0 Measurement (Admittance)

Setting Values

Direction method of measurement			G0 B0	-
Release threshold value 3I0>	Protection-class current transformers	For I_{rated} = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For I_N transformer type sensitive and I_{rated} = 1 A	For I_{rated} = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For I_N transformer type sensitive and I_{rated} = 5 A	For I_{rated} = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For I_{rated} = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Threshold value V0>			0.300 V to 200.000 V	Increments of 0.001 V
Threshold value Y0>			0.10 mS to 100.00 mS	Increments of 0.01 mS
Time delay of direction determination			0.00 s to 60.00 s	Increments of 0.01 s
α1 constraint of direction range α2 constraint of direction range			1° to 15°	Increments of 1°
Angle correction φ			-45° to 45°	Increments of 1°
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

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

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undercurrent/undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[11] at 50 Hz Approx. 29 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

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

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Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1 A) or 0.25 mS (I_{rated} = 5 A), (I_{rated} = ± 10 %)

11.10.6 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Setting Values

Threshold value[57]	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01
V> healthy ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V< healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

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

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

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[58] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.0 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Frequency Operating Range

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

Tolerances

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

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

11.10.7 Non-Directional 3I0 Stage

Setting Values

Method of measurement			Fundamental component RMS value	
Threshold value 3I0>	Protection-class current transformers	For $I_{ph,rated}$ = 1 A	0.030 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.15 A to 175.00 A	Increments of 0.01 A
	For transformer type I-sensitive and $I_{ns,rated}$ = 1 A	For $I_{ph,rated}$ = 1 A	0.001 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.001 A to 175.000 A	Increments of 0.001 A
	For transformer type I-sensitive and $I_{ns,rated}$ = 5 A	For $I_{ph,rated}$ = 1 A	0.005 A to 35.000 A	Increments of 0.001 A
		For $I_{ph,rated}$ = 5 A	0.005 A to 175.000 A	Increments of 0.001 A
Pickup delay			0.00 s to 60.00 s	Increments of 0.01 s
Tripping delay			0.00 s to 60.00 s	Increments of 0.01 s

Dropout

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

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

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[59] at 50 Hz Approx. 23 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

11.10.8 Non-Directional Y0 Stage

Setting Values

V0> threshold value	0.300 V to 200.000 V	Increments of 0.001 V
Threshold Y0>	0.10 mS to 100.00 mS	Increments of 0.01 mS

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

Pickup delay	0.00 s to 60.00 s	Increments of 0.01 s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

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

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 32 ms + OOT[60] at 50 Hz Approx. 26 ms + OOT at 60 Hz
Extension of operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 32 ms + OOT at 50 Hz Approx. 27 ms + OOT at 60 Hz

Tolerances

Admittance	1 % of the setting value or 0.05 mS (I_{rated} = 1.6 A) or 0.25 mS (I_{rated} = 8 A), (I_{rated} = ± 10 %)

[60] OOT (Output Operating Time) additional delay of the output medium used, see chapter 11.1.4 Relay Outputs

11.11 Distance Protection

Residual Compensation

Kr	-0.33 to 11.00	Increments of 0.01
Kx	-0.33 to 11.00	Increments of 0.01
K0	0.000 to 11.000	Increments of 0.001
Angle (K0)	-180.00° to +180.00°	Increments of 0.01
	Configurable separately for each zone	

Parallel-Line Matching

RmR	0.00 to 8.00	Increments of 0.01
XmX	0.00 to 8.00	Increments of 0.01
Km0	0.000 to 8.000	Increments of 0.001
Angle (Km0)	-180.00° to +180.00°	Increments of 0.01

Phase Preference

For double ground faults in a grounded system	Block leading phase from ground Block lagging phase from ground Release all loops involved Release phase to ground loops involved Release phase-to-phase loops involved
For double ground faults in isolated or resonant-grounded system	C(A) acyclical A(C) acyclical B(A) acyclical A(B) acyclical C(B) acyclical B(C) acyclical C(A) cyclical A(C) cyclical All loops involved

Ground-Fault Detection

Threshold value 3I0>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
Threshold value V0>		0.300 V to 200.000 V	Increments of 0.001 V
Measurement tolerances for sinusoidal measurands		± 5%	

Pickup Method

Overcurrent Pickup			
Iph>>	1 A @ 50 and 100 Irated	0.250 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	1.25 A to 175.00 A	Increments of 0.01 A
Dropout ratios		Approx. 0.95	
Measurement tolerances for sinusoidal measurands		± 5%	

Voltage and phase angle-dependent current pickup (V/I/φ) (optional)			
Characteristic		Cascaded with adjustable slopes	
Minimum phase current Iph>	1 A @ 50 and 100 Irated	0.100 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.50 A to 175.00 A	Increments of 0.01 A
Current in short circuit angle range Iφ	1 A @ 50 and 100 Irated	0.100 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.50 A to 175.00 A	Increments of 0.01 A
Undervoltage phase-to-ground (individually separated according to Iph>, Iph>>, and Iφ>)		0.500 V to 200.000 V	Increments of 0.001 V
Undervoltage phase-to-phase (individually separated according to Iph>, Iph>>, and Iφ>)		1.000 V to 200.000 V	Increments of 0.001 V
Lower threshold angle φ>		30.0° to 60.0°	Increments of 0.1°
Upper threshold angle φ<		90.0° to 120.0°	Increments of 0.1°
Dropout ratios			
Iph>, Iφ>		Approx. 0.95	
Phase-to-ground voltage Phase-to-phase voltage		Approx. 1.05	
Measurement tolerances for sinusoidal measurands			
Amounts of V, I		± 5 %	
Angle φ		± 3°	
Impedance pickup (optional)			
Minimum phase current Iph>	1 A @ 50 and 100 Irated	0.050 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.25 A to 175.00 A	Increments of 0.01 A
Under consideration of the respective direction, the limits of the zones that are set the furthest, are the most important ones.			
Dropout ratio		Approx. 1.05	

Distance Measurement

Characteristic		Quadrilateral or MHO characteristic	
Minimum phase current I>	1 A @ 50 and 100 Irated	0.050 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.25 A to 175.00 A	Increments of 0.01 A
$φ_{Dist}$ = Angle of distance-protection characteristic		30.0° to 90.0°	Increments of 0.1°
Quadrilateral setting ranges			
X reach – reach of reactance	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
R (ph-ph) – Phase-to-phase resistance reserve	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
R (ph-gnd) – Phase-to-ground resistance reserve	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
$α_{Pol}$ – Zone inclination		0° to 45°	Increments of 1°

Direction determination for polygon:			
For all fault types		With actual short-circuit, buffered or cross-polarized voltages	
Directional sensitivity		Dynamically unlimited, stationary about 1 V	
Every zone can be configured as forward, reverse, or non-directional.			
Setting ranges for MHO characteristic:			
Z, impedance range	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
Polarization		With buffered or cross-polarized voltages	
Every zone can be configured as forward or backward.			
Load cutout (for impedance pickup):			
R_{load} – Minimum load resistance	For I_{rated} = 1 A	0.050 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.010 Ω to 120.000 Ω	
φload – Maximum load angle		20.0° to 60.0°	Increments of 0.1°
Dropout Ratios			
- Currents		Approx. 0.95	
- Impedances		Approx. 1.05	
Measured-value correction		For ground-current coupling in parallel lines	
Measurement tolerances for sinusoidal measurands		$\left\|\frac{\Delta X}{X}\right\| \leq 5\%$ for $30° \leq φ_{SC} \leq 90°$	
		$\left\|\frac{\Delta R}{R}\right\| \leq 5\%$ for $0° \leq φ_{SC} \leq 60°$	
		$\left\|\frac{\Delta Z}{Z}\right\| \leq 5\%$ for $-30° \leq φ_{SC} - φ_{line} \leq 30°$	

Times

Shortest operate time	Approx. 9 ms + OOT[61] at 50 Hz Approx. 8 ms (60 Hz) + OOT	
Dropout time	Approx. 40 ms	
Incremental times	0.00 s to 60.00 s; ∞ for all zones	Increments of 0.01 s
Timer tolerance	1 % of the setting value or 10 ms	
The times set are pure time delays.		

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$0.8 \leq f/f_{rated} < 0.9$ $1.1 < f/f_{rated} \leq 1.2$	Slightly expanded tolerances
f < 0.8 f_{rated} f > 1.2 f_{rated}	Active

[61] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

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11.12 Impedance Protection

Setting Values

Min. phase-current thresh	1 A @ 100 Irated	0.030 A to 100.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 500.00 A	Increments of 0.01 A
	1 A @ 50 Irated	0.030 A to 50.000 A	Increments of 0.001 A
	5 A @ 50 Irated	0.15 A to 250.00 A	Increments of 0.01 A
X reach (ph-g) – reach of reactance, phase to ground	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.020 Ω to 120.000 Ω	Increments of 0.001 Ω
X reach (ph-ph) – reach of reactance, phase-to-phase	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.020 Ω to 120.000 Ω	Increments of 0.001 Ω
R reach (ph-g) – reach of resistance, phase to ground	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.020 Ω to 120.000 Ω	Increments of 0.001 Ω
R reach (ph-ph) – reach of resistance, phase-to-phase	For I_{rated} = 1 A	0.100 Ω to 600.000 Ω	Increments of 0.001 Ω
	For I_{rated} = 5 A	0.020 Ω to 120.000 Ω	Increments of 0.001 Ω

Dropout Ratios

Currents	About 0.95
Voltage	About 1.05
Impedances	About 1.05

Times

Operate time with time delay = 0 ms	Approx. 30 ms + OOT [1] at 50 Hz Approx. 26 ms + OOT at 60 Hz
Dropout time	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltage	0.5 % of the setting value or 0.05 V
Impedances Measurement tolerances for sinusoidal values	$\left\|\frac{\Delta X}{X}\right\| \le 5\%$ for 30° ≤ φ_{sc} ≤ 90°
	$\left\|\frac{\Delta R}{R}\right\| \le 5\%$ for 0° ≤ φ_{sc} ≤ 60°

[1] OOT (Output Operating Time) additional delay of the used output medium, such as 5 ms with quick-acting relay

11.13 Power-Swing Blocking

General

Measuring principle	Cyclic supervision of impedance curves for monotony, continuity, and jump
Detectable power swing frequency	0.1 Hz to 12 Hz for symmetrical operation, up to 7 Hz during 1-pole dead times and unbalanced faults
Power-swing blocking	Can be set separately for each distance-protection zone

Times

Power-swing detection time	≤ 2.5 power-system cycles
Dropout time	≥ 5.5 power-system cycles in case of unbalanced faults ≥ 5.5 power-system cycles in case of balanced faults (max. 5 s after leaving the pickup range of the distance protection)

11.14 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 [2]

Tolerance

Sequence tolerance for delay times	1 % of the setting value or 10 ms

[2] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays, see chapter 11.1.4 Relay Outputs

11.15 Overcurrent Protection, Phases

11.15.1 Stage with Definite-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value [3]	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 [4] 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

[3] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$
[4] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ 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) [5] (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 %) [6]
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 %) [7]
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 %) [8]
Time delays	1 % of the setting value or 10 ms

[illegible]

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.15.2 Stage with Inverse-Time Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Pickup delay		0.00 s to 60.00 s	Increments of 0.01 s
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

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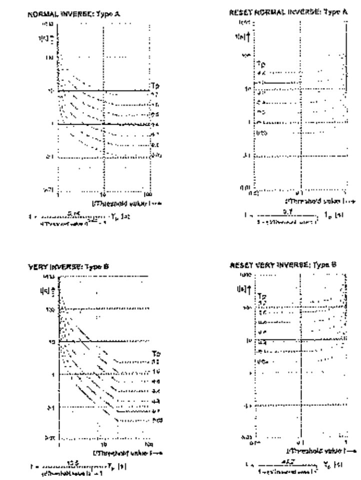


Figure 11-8 Operate Curves and Dropout-Time Characteristic Curves According to IEC

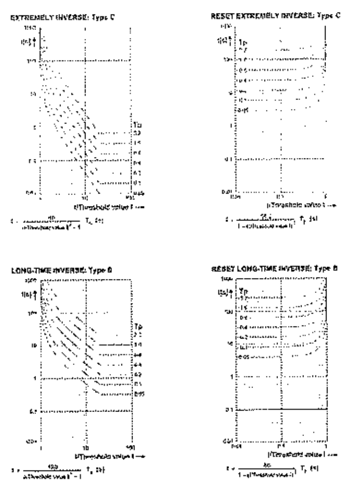


Figure 11-9 Operate Curves and Dropout-Time Characteristic Curves According to IEC

Operate Curves and Dropout Time Characteristic Curves According to ANSI/IEEE

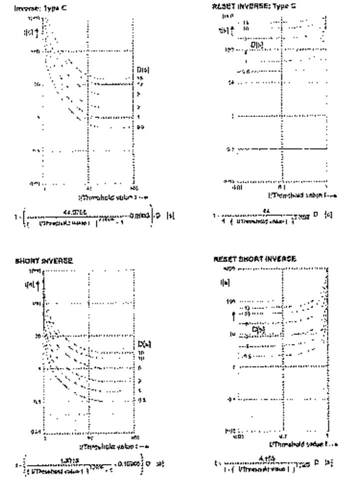


Figure 11-10 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

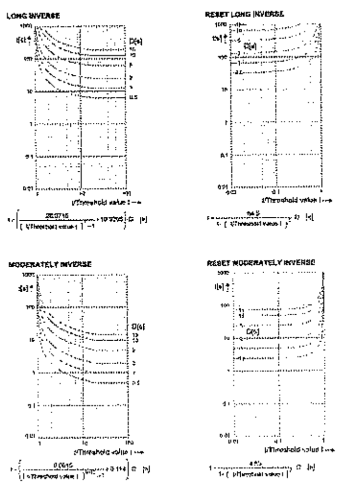


Figure 11-11 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

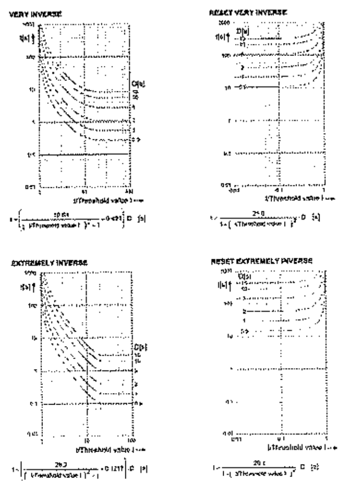
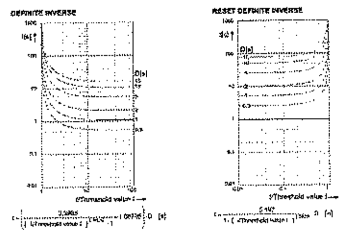


Figure 11-12 Tripping Characteristic Curves and Dropout Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead of the I threshold.

Figure 11-13 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 50th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

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Up to 50th harmonic, f_{rated} = 50 Hz	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation) (33 % harmonics, in relation to the fundamental component)	
Up to 30th harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)[3]
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 %)[4]
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 %)[5]
Operate time for 2 ≤ I/threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for 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 %

11.15.3 Stage with User-Defined Characteristic Curve

Setting Value for the Function Block Filter

h(0)	-100.000 to 100.000	Increments of 0.001
h(1)	-100.000 to 100.000	Increments of 0.001
h(2)	-100.000 to 100.000	Increments of 0.001
h(3)	-100.000 to 100.000	Increments of 0.001
h(4)	-100.000 to 100.000	Increments of 0.001

Setting Values for Protection Stage

Method of measurement		Fundamental component RMS value	
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–

[2] In case that the filter response exactly matches the user-defined gain factors
[3] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.
[4] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.
[5] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.

Time multiplier	0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve	2 to 30	Increments of 1
X values of the operate curve	1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve	0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve	2 to 30	Increments of 1
X values of the dropout characteristic curve	0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve	0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value, no filter applied (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Currents, method of measurement = RMS value with filter for the compensation of the amplitude attenuation due to the anti-aliasing filter (33 % harmonics, in relation to the fundamental component)	
Up to 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	2 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value with filter for the gain of harmonics (including compensation of the amplitude attenuation)[6] (33 % harmonics, in relation to the fundamental component)	
Up to 30th harmonic	1.5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)[7]
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)[8]
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)[9]
Operate time for 2 ≤ I/threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Time delays	1 % of the setting value or 10 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[6] In case that the filter response exactly matches the user-defined gain factors
[7] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.
[8] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.
[9] In case that the user-defined gain factor is set below 2. The tolerance increases, if the gain factor is larger.

11.16 Overcurrent Protection, Ground

11.16.1 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[10]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[11] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

[10] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 I_{rated}
[11] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

Tolerances

3I0 measured via I4[12], 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[12], 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 %

11.16.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	–
Threshold value[14]	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
Minimum time of the curve		0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

[12] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2
[13] Slightly expanded tolerances will occur during the calculation of 3I0, maximum factor of 2
[14] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 I_{rated}

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

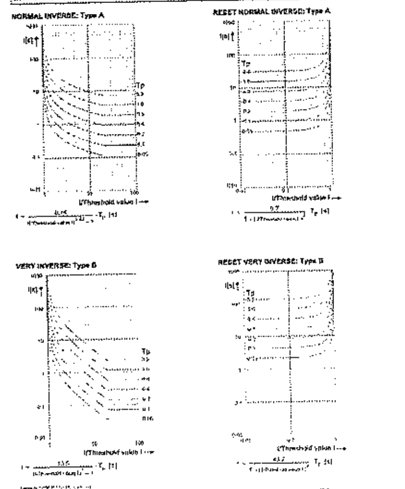

Figure 11-4 Operate Curves and Dropout-Time Characteristic Curves According to IEC

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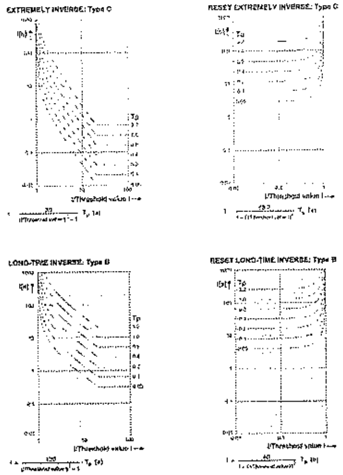


Figure 11-15 Operate Curves and Dropout-Time Characteristic Curves According to IEC

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

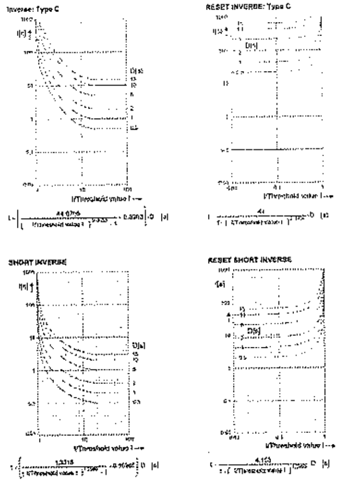


Figure 11-16 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

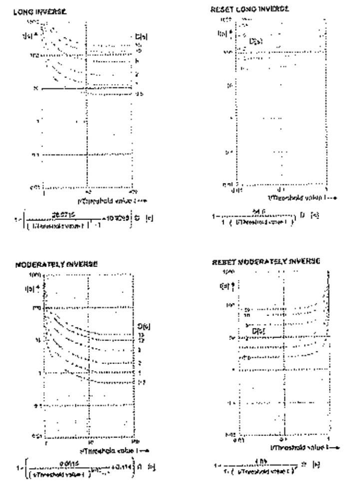


Figure 11-17 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

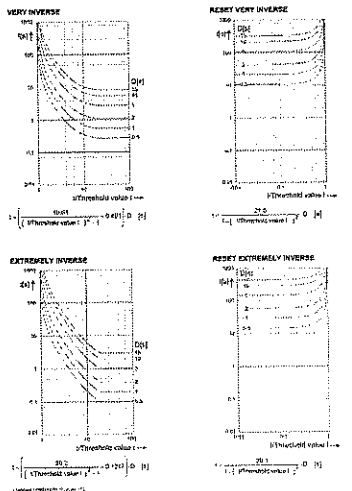
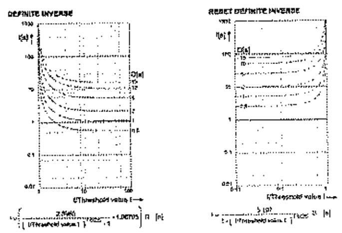


Figure 11-18 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE



Note: IGnd threshold stands for ground fault instead of the I threshold

Figure 11-19 Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10 Hz \leq f < 0.9 f_{rated}$ $1.1 f_{rated} < f \leq 80 Hz$	Slightly expanded tolerances
$f < 10 Hz$ $f > 80 Hz$	Active

Tolerances

3I0 measured via I4[5], 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 %)
3I0 measured via I4[5], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} = 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

[5] In principle, increased tolerances will occur during the calculation of 3I0, maximum factor of 2

Dropout time for 2 ≤ I/threshold value I ≤ 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 %

11.16.3 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10 Hz \leq f < 0.9 f_{rated}$ $1.1 f_{rated} < f \leq 80 Hz$	Slightly expanded tolerances

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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[1], method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

[1] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2
[2] Insignificantly increased tolerances will occur during the calculation of 3I0, maximum factor of 2

11.17 Stage with Definite-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value[3]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.95	-
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 16 ms + OOT[4] 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 ≤ 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 %)

[3] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$.
[4] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

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 %

11.18 Stage with Inverse-Time Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value[5]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush current detection	Approx. 10 ms

The tripping characteristic curves and dropout characteristic curves according to IEC can be found in the Technical Data chapter under Inverse Time-Overcurrent Protection.

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

The tripping characteristic curves and dropout characteristic curves according to ANSI/IEEE can be found in the Technical Data chapter under Inverse Time-Overcurrent Protection.

Frequency Operating Range

0.9 ≤ 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

[5] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$.

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.19 Stage with User-Defined Characteristic Curve

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with less sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with transformer inrush-current detection	Approx. 10 ms

11.20 Overcurrent Protection, 1-Phase (Fast Stage)

Setting Values

Threshold value	1 A @ 50 and 100 rated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 rated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 rated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 rated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio (fixed)		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 8 ms + OOT[66]
Dropout time	Approx. 25 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

Pickup tolerance, current	5 % of the setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

[66] OOT (Output Operating Time) additional time delay of the output medium used, for example, 5 ms with fast relay

11.21 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		0.00 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[67]	1.01 to 1.20	Increments of 0.01
Undervoltage threshold value[67]	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[67]	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[67]	150 mV sec.

Reset of the Integration Timer for Inverse Time-Overcurrent Stages

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

[67] This value is for the inverse time-overcurrent voltage-released stage.

Dropout for Definite Time-Overcurrent Stages

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent/overvoltage and of 105 % for undervoltage functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)
Voltage transformer	150 mV sec.

Operate Curves and Dropout-Time Characteristic Curves According to IEC

Extension of the operate time during operation with inrush-current detection	Approx. 10 ms

The operate curves and dropout-time characteristic curves according to IEC can be found in the chapter Technical Data under Inverse-Time Overcurrent Protection.

Operate Curves and Dropout-Time Characteristic Curves According to ANSI/IEEE

The operate curves and dropout-time characteristic curves according to IEC can be found in the chapter Technical Data under Inverse-Time Overcurrent Protection.

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % part of harmonic in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Voltage	0.5 % of the setting value or 0.05 V
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.22 Directional Overcurrent Protection, Phases

11.22.1 Stage with Definite-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value[68]	1 A @ 50 and 100 rated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 rated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 rated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 rated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT[69] at 50 Hz Approx. 22 ms + OOT at 60 Hz

[68] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 I_{rated}.

[69] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

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
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 %)
Time delay	1 % of the setting value or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.22.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Rotation angle of the reference voltage		-180° to +180°	Increments of 1°
Directional mode		Forward Backward	–
Method of measurement		Fundamental component RMS value	–
Threshold value[72]	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	–

[72] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$

Time multiplier	0.05 to 15.00	Increments of 0.01
Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-8
Very inverse: type B	
Extremely inverse: type C	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-9
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-10
Short inverse	
Long inverse	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-11
Moderately inverse	
Very inverse	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-12
Extremely inverse	
Definite inverse	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-13

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT 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

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.22.3 Stage with User-Defined Characteristic Curve

Setting Values

Rotation angle of the reference voltage	-180° to +180°	Increments of 1°
Directional mode	Forward Reverse	–
Method of measurement	Fundamental component RMS value	–

OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Threshold value[73]	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	–
Time multiplier		0.05 to 15.00	Increments of 0.01
Number of value pairs for the operate characteristic curve		2 to 30	Increments of 1
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Direction Determination

Type	With externally generated voltages With voltage memory 2 s
Forward range	$V_{ref,rot}$ ±88°
Dropout differential forward/reverse range	1°
Directional sensitivity	Unlimited for 1 and 2-phase short circuits Dynamically unlimited, stationary for 3-phase short circuits Approx. 13 V phase-to-phase

Times

Operate time with time delay = 0 ms	Approx. 37 ms + OOT 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

[73] If you have selected the method of measurement = RMS value, do not set the threshold value under 0.1 $I_{rated,sec}$
OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % harmonics, in relation to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value +2 % current tolerance or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.23 Directional Overcurrent Protection, Ground

11.23.1 Stage with Definite-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	–
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Directional mode		Forward Reverse	–
Method of measurement		Fundamental component RMS value	–
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout ratio		0.90 to 0.99	Increments of 0.01
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances

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10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Time delays	1 % of the setting value or 10 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.23.2 Stage with Inverse-Time Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Type of characteristic curve		Characteristic curves according to IEC and ANSI	
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.00 to 15.00	Increments of 0.01

Minimum time of the curve	0.00 s to 1.00 s	Increments of 0.01 s
Additional time delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · Threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · Threshold value

Operate Curves and Dropout-Time Characteristic Curves according to IEC

Normal inverse: type A	Refer to the respective figure of the technical data for the non-dir.-OC-ground function 11.26.2 Stage with Inverse-Time Characteristic Curve
Very inverse: type B	
Extremely inverse: type C	
Long-time inverse: type B	

Operate Curves and Dropout-Time Characteristic Curves according to ANSI/IEEE

Inverse: type C	Refer to the respective figure of the technical data for the non-dir. OC ground function 11.26.2 Stage with Inverse-Time Characteristic Curve
Short inverse	
Long inverse	
Moderately inverse	
Very inverse	
Extremely inverse	
Definite inverse	

Times

The maximum pickup time with operate delay = 0 ms	Approx. 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 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 < I/I threshold value < 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value < 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.23.3 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Characteristic curve: see Figure 11-20			
Threshold value multiplier		1.00 to 4.00	Increments of 0.01
Time multiplier		0.000 s to 60.000 s	Increments of 0.001 s
Minimum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s
Maximum time of the characteristic curve		0.000 s to 60.000 s	Increments of 0.001 s

Additional time delay	0.000 s to 60.000 s	Increments of 0.001 s

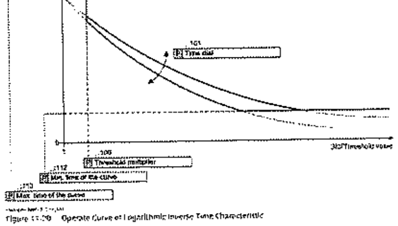

Figure 11-20 Operate Curve of Logarithmic Inverse-Time Characteristic

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

The maximum pickup time with operate delay = 0 ms	Approx. 30 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

0.9 ≤ f/f_{rated} ≤ 1.1	According to specified tolerances

10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Inverse-time operate time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse-time characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	< 5 %

11.23.4 Stage with Knee-Point Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Characteristic curve: see Figure 11-21		
Minimum time of the characteristic curve	0.00 s to 30.00 s	Increments of 0.01 s
Knee-point time of the curve	0.00 s to 100.00 s	Increments of 0.01 s
Maximum time of the characteristic curve	0.00 s to 200.00 s	Increments of 0.01 s
Knee-point value	0.030 A to 35.000 A	Increments of 0.001 A
Current at maximum time of the curve	0.030 A to 35.000 A	Increments of 0.001 A
Time multiplier	0.05 to 1.50	Increments of 0.01

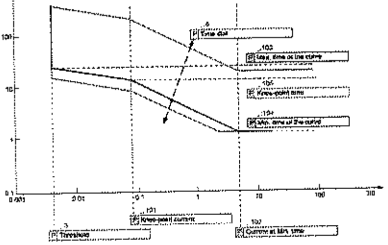

Figure 11-21 Operate Curve of the Logarithmic Inverse Time with Knee-Point Characteristic (in the Example of Threshold = 0.004 A)

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

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Times

The maximum pickup time with operate delay = 0 ms	Approx. 29 ms + OOT at 50 Hz Approx. 25 ms + OOT at 60 Hz
Extension of the operate time during operation with inrush-current detection	Approx. 10 ms
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Inverse-time operate time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Inverse-time dropout time to logarithmic inverse time with knee-point characteristic	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	≤ 5 %

11.23.5 Stage with User-Defined Characteristic Curve

Setting Values for the Function Direction Determination

Method for direction determination	Zero sequence Negative sequence	-
Minimum V0 or V2 threshold	0.150 V to 20.000 V	0.001 V
Rotation angle of the reference voltage	-180° to 180°	1°
Forward range	0° to 180°	1°

Setting Values

Direction mode		Forward Reverse	-
Method of measurement		Fundamental component RMS value	-
Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Dropout		Disk emulation Instantaneous	-
Time multiplier		0.05 to 15.00	Increments of 0.01
X values of the operate curve		1.00 p.u. to 66.67 p.u.	Increments of 0.01 p.u.
Y values of the operate curve		0.00 s to 999.00 s	Increments of 0.01 s
Number of value pairs for the dropout characteristic curve		2 to 30	Increments of 1
X values of the dropout characteristic curve		0.05 p.u. to 0.95 p.u.	Increments of 0.01 p.u.
Y values of the dropout characteristic curve		0.00 s to 999.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout	95 % of 1.1 · threshold value
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Reset of the Integration Timer

Instantaneous	With dropout
Disk emulation	Approx. < 0.90 · threshold value

Times

The maximum pickup time with operate delay = 0 ms	Approx. 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

$0.9 \le f/f_{rated} \le 1.1$	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 with reduced sensitivity

Tolerances

Currents, method of measurement = fundamental component	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Currents, method of measurement = RMS value (33 % part of harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 50 Hz	3 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Up to 50th harmonic, f_{rated} = 60 Hz	4 % of the setting value or 20 mA (I_{rated} = 1 A) or 100 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Operate time for 2 ≤ I/I threshold value ≤ 20	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Dropout time for I/I threshold value ≤ 0.90	5 % of the reference (calculated) value + 2 % current tolerance or 30 ms
Direction-determination angle error	1°

Influencing Variables for Thresholds

Transient excess pickup in method of measurement = fundamental component, for τ > 100 ms (with complete unbalance)	≤ 5 %

11.24 Negative-Sequence Protection

11.24.1 Stage with Definite-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated,obj}$ Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout ratio		0.40 to 0.99	Increments of 0.01
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

- Dropout differential derived from the parameter Dropout ratio
- Dropout differential of 3 % of the 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

Current Operating Range

Current range	At least one phase current ≥ setting value I_{min} All phase currents ≤ setting value $I_{ph, max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

[1] OOT (Output Operating Time) additional delay of the output medium used, see chapter 11.1.4 Relay Outputs

Tolerances

Pickup value	
$I_2/I_{rated,obj}$	Approx. 2 % of the setting value or 0.8 % of the absolute value
I_2/I_1	Approx. 2 % of the setting value or 4 % of the absolute value (I_1 > 50 mA (I_{rated} = 1 A) or 250 mA (I_{rated} = 5 A))
Time delays	1 % of the setting value or 10 ms

11.24.2 Stage with Inverse-Time Characteristic Curve

Setting Values

Reference value for I_2 (I_{ref})		Rated object current $I_{rated,obj}$ Positive-sequence current I_1	
Pickup value		5.0 % to 999.9 % I_2/I_{ref}	Increments of 0.1
Dropout		Disk emulation Instantaneous	
Time multiplier		0.05 to 15.00	Increments of 0.01
Release current (minimum current release)	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Maximum phase current (maximum current limiting)	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

- Dropout differential derived from the parameter Dropout ratio
- Dropout differential of 3 % of the object rated current

Times

Pickup time	Approx. 40 ms + OOT[2] 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

[2] OOT (Output Operating Time) additional delay of the output medium used, see chapter 11.1.4 Relay Outputs

Operate and Dropout Characteristic Curves

You can select from the following operate and dropout characteristic curves:

Table 11-3 Standard Characteristic Curves to IEC

Normal inverse: type A	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-8
Very inverse: type B	
Extremely inverse: type C	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-9
Long-time inverse: type B	

Table 11-4 Standard Characteristic Curves to ANSI

Inverse: type C	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-10
Short inverse	
Long inverse	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-11
Moderately inverse	
Very inverse	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-12
Extremely inverse	
Definite inverse	See chapter 11.15.2 Stage with Inverse-Time Characteristic Curve, Figure 11-13

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_{min} All phase currents ≤ setting value $I_{ph, max}$

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

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 (I_1 > 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

11.25 Undercurrent Protection

Setting Values

Method of measurement		Fundamental component RMS value	-
Threshold value I<	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Time delay		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz

Frequency Operating Range

0.9 ≤ 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 setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)
Currents, method of measurement = RMS value (33 % portion harmonic, referring to fundamental component)	
Up to 30th harmonic	1 % of setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A), (f_{rated} ± 10 %)

[1] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays, see Chapter Relay Outputs

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 %)
Time delays	1 % of the setting value or 10 ms

11.26 Overexcitation Protection

Setting Values

Threshold value (characteristic curve dependent on pickup)		$\frac{U/U_{rated}}{f/f_{rated}}$	1.00 to 1.20	Increments of 0.01
Threshold value (characteristic curve independent on pickup)		$\frac{U/U_{rated}}{f/f_{rated}}$	1.00 to 1.40	Increments of 0.01
Time delay (warning delay and tripping delay)			0.00 s to 60.00 s	Increments of 0.01 s
Characteristic value pairs			2 to 30	
	Value ranges	V/f	1.00 p.u. to 10.00 p.u.	Increments of 0.01 p.u.
		t	0 s to 100 000 s	Increments of 1 s
Cooling time thermal replica			0 s to 100 000 s	Increments of 1 s

Functional Measured Values

Measured Value	Description
(_:2311:322) V/f	Value calculated from voltage and frequency.
(_:2311:323) Therm. charact.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, tripping occurs.

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

Operating Times

Operate times/dropout times		
Operate time at frequency	50 Hz	60 Hz
Minimum	31 ms + OOT[2]	30 ms + OOT[2]
Dropout time	30 ms + OOT[2]	30 ms + OOT[2]

Dropout Ratios

Warning, tripping (independent stage)	Approx. 0.98

Operate Curve

Thermal replica	For default setting refer to the following characteristic curve (Figure 11-22)

Tolerances

V/f pickup	2 % of the setting value
Time delays	1 % of the setting value or 10 ms (min. 1.5 periods)
Thermal replica	5 % based on V/f ± 600 ms

[2] refer to protection functions, for example overcurrent protection

Voltage measurement accuracy	0.5 % of the setting value or 0.5 V in the range f_n ± 10 %
Frequency measurement accuracy	1.0 % of the setting value or 1.0 Hz in the frequency range 10 Hz to 80 Hz

Influencing Quantities

Auxiliary direct voltage in the 0.8 range	≤ 1 %
Time delays	≤ 0.5 %/10 K
Thermal replica	≤ 1 %
Harmonics	
Up to 10 % of 3rd harmonic Up to 10 % of 5th harmonic	≤ 1 % ≤ 1 %

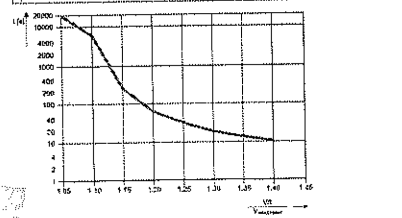

Figure 11-22 Operate Curve from the Thermal Replica of the Overexcitation Protection (Default Setting)

11.27 Unbalanced-Load Protection

Setting Values

Maximum continuously perm. I2	3.0 % to 30.0 % I2/$I_{rated,machine}$	Increments of 0.1 %
Unbalanced load factor K	1.0 s to 100.0 s	Increments of 0.1 s
Warning delay	0.0 s to 60.0 s; ∞	Increments of 0.1 s
Cooling time thermal replica	0 s to 50 000 s	Increments of 1 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

- Dropout differential derived from a dropout ratio of 95 %
- Dropout differential of 3 % of the object rated current

Operate Characteristics

Characteristic of the thermal replica	$t_{Operate} = \frac{K}{(I_2/I_{rated,machine})^2}$	
Where:	$t_{Operate}$	Permissible application time of the negative-sequence current
	K	Unbalanced load factor K
	$I_2/I_{rated,machine}$	Unbalanced load (negative-sequence current/rated current of the machine)

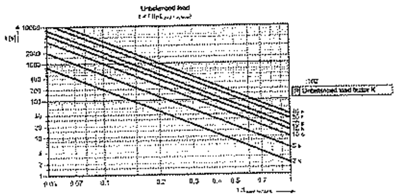

Figure 11-23 Thermal Characteristic for Unbalanced-Load Protection

Times

Pickup time of the warning stage	Approx. 50 ms + OOT[3] at 50 Hz Approx. 50 ms + OOT at 60 Hz

[3] OOT (Output Operating Time) additional delay of the output medium used, for example, 5 ms with fast relays

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Dropout time	Approx. 50 ms or better

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Negative-sequence current I_2	Approx. 3 % of setting value or 0.030 A at I_{rated} = 1 A Approx. 3 % of setting value or 0.150 A at I_{rated} = 5 A
Warning delay	1 % of the setting value or 10 ms
Time for $2 < I_2/I_{2,max} < 20$	5 % of reference (calculated) value or 100 ms + (1 % current tolerance or 10 mA) at I_{rated} = 1 A 5 % of reference (calculated) value or 100 ms + (1 % current tolerance or 50 mA) at I_{rated} = 5 A

Influencing Variables for the Thresholds

Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

11.28 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[49]

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

[49] OOT (Output Operating Time) Additional delay of the output medium used, see Chap. 11.1.4 Relay Outputs

11.29 Overvoltage Protection with 3-Phase Voltage

Setting Values for Stage Type Definite Time-Overvoltage Protection

Measured value	Phase-to-phase Phase-to-ground	
Method of measurement	Fundamental component RMS value	
Pickup mode	1 out of 3 3 out of 3	
Pickup value[50]	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

[50] 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[51] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances for Stage Type Definite Time-Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

Tolerances for Stage Type Inverse Time-Overvoltage Protection

Voltages	0.5 % of the setting value or 0.05 V
Operate time for 1.2 ≤ V/V threshold value ≤ 20	5 % of the setting value or 30 ms
Reset time delay	1 % of the setting value or 10 ms

[51] OOT (Output Operating Time) Additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.30 Overvoltage Protection with Positive-Sequence Voltage

Setting Values

Pickup value	0.300 V to 200.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value – dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[52] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[52] OOT (Output Operating Time) Additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.31 Overvoltage Protection with Negative-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 10 cycles	Increments of 1 cycle

Setting Values

Pickup value of V2	0.300 V to 200.000 V	Increments of 0.001 V
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value – dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup times	55 ms to 230 ms + OOT[53] (depends on the measuring-window length) at 50 Hz 48 ms to 195 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout time	20 ms to 70 ms + OOT (depends on the measuring window length)

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[53] OOT (Output Operating Time) Additional delay of the output medium used, see Chapter [illegible]

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11.32 Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

Setting Values for the Function

Measuring window	1 cycle to 30 cycles	Increments of 1 cycle
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V

Setting Values for Stage Types

Pickup value of V2/V1	0.50 % to 100.00 %	Increments of 0.01 %
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.90 to 0.99	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec

Times

Pickup times	50 ms to 210 ms + OOT[1] (depends on the measuring-window length) at 50 Hz 43 ms to 190 ms + OOT (depends on the measuring-window length) at 60 Hz
Dropout times	22 ms to 55 ms + OOT (depends on the measuring-window length) at 50 Hz 18 ms to 45 ms + OOT (depends on the measuring-window length) at 60 Hz

Frequency Operating Range

0.9 f_{rated} to 1.1 f_{rated}	According to specified tolerances
10 Hz to 0.9 f_{rated} 1.1 f_{rated} to 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Voltages	0.50 % of the setting value or 0.050 V
Time delays	1.00 % of the setting value or 10 ms

[1] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

11.33 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

Setting Values

Method of measurement	RMS value Fundamental component Fundamental component over 2 cycle filters	
Block. on measuring-voltage outage	Yes No	
Determ. ph. aff. by gnd. flt.	Yes No	
Threshold 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
Pickup delay	0.00 s to 320.00 s	Increments of 0.01 s
Dropout Ratio	0.90 to 0.99	Increments of 0.01
V< faulty ph-gnd vltg.	0.300 V to 200.000 V	Increments of 0.001 V
V> healthy ph-gnd. vltg.	0.300 V to 200.000 V	Increments of 0.001 V

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	
Standard filter, true RMS	Approx. 25 ms + OOT[3] at 50 Hz Approx. 22 ms + OOT at 60 Hz
2 cycle filters	Approx. 45 ms + OOT at 50 Hz Approx. 39 ms + OOT at 60 Hz
Dropout Time	
Standard filter, true RMS	Approx. 20 ms + OOT at 50 Hz Approx. 16.6 ms + OOT at 60 Hz
2 cycle filters	Approx. 31.06 ms + OOT at 50 Hz Approx. 27.06 ms + OOT at 60 Hz

Frequency Operating Range

0.9 ≤ 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

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[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

11.34 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 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 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[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} ≤ 1.1	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Active

Tolerances

Voltages	0.5 % of the setting value or 0.05 V

[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

Time delays	1 % of the setting value or 10 ms

11.35 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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$$T_{Inv} = T_p \left(\frac{k}{1 - \left(\frac{V}{V_{Thresh}}\right)^{\alpha}} + c \right) [s]$$

Where

T_{Inv}	Inverse time delay
T_p	Time multiplier (parameter Time dial)
V	Measured undervoltage
V_{Thresh}	Threshold value (parameter Threshold)
k	Curve constant k (parameter Charact. constant k)
α	Curve constant α (parameter Charact. constant α)
c	Curve constant c (parameter Charact. constant c)

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies.

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive, maintained: Dropout of the pickup ensured 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

11.36 Undervoltage Protection with Positive-Sequence Voltage

Setting Values

Measured value		Phase-to-phase Phase-to-ground	
Method of measurement		Fundamental component RMS value	
Current-flow criterion		On Off	
Threshold value I>	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Pickup value		0.300 V to 175.000 V	Increments of 0.001 V
Time delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio		1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies.

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time	Approx. 25 ms + OOT[1] at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 20 ms + OOT

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances
$f < 10\ Hz$ $f > 80\ Hz$	Inactive, maintained: Dropout of the pickup induced by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V

[1] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

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

11.37 Undervoltage Protection with Any Voltage

Setting Values

Measured value	Measured phase-to-ground voltage V_A Measured phase-to-ground voltage V_B Measured phase-to-ground voltage V_C Measured phase-to-phase voltage V_{AB} Measured phase-to-phase voltage V_{BC} Measured phase-to-phase voltage V_{CA} Calculated phase-to-phase voltage V_{AB} Calculated phase-to-phase voltage V_{BC} Calculated phase-to-phase voltage V_{CA} Calculated voltage V0	
Method of measurement	Fundamental component RMS value	
Pickup value[1]	0.300 V to 340.000 V	Increments of 0.001 V
Time delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	1.01 to 1.20	Increments of 0.01

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies.

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT[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
$f < 10\ Hz$ $f > 80\ Hz$	Inactive, maintained: Dropout of the pickup ensured by blocking or by increasing the measurand beyond the dropout threshold

Tolerances

Voltages	0.5 % of the setting value or 0.05 V
Time delays	1 % of the setting value or 10 ms

[1] If you have selected the method of measurement = RMS value, do not set the threshold value under 10 V.
[2] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.38 Undervoltage-Controlled Reactive-Power Protection

Setting Values

Threshold value	Power Q	1.00 % to 200.00 %	Increments of 0.01 %
	Voltage of protection stage	3.000 to 175.000	Increments of 0.001 V
	Voltage of reclosure stage	3.000 V to 340.000 V	Increments of 0.001 V
Current I_1 release threshold	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Operate delay		0.00 s to 60.00 s	Increments of 0.01 s
Release time delay of reclosure stage		0.00 s to 3600.00 s	Increments of 0.01 s

Dropout Ratio

Protection stage	
Reactive-power flow Q	Approx. 0.95
Voltage	Approx. 1.05
Release current	Approx. 0.95

Reclosure stage	
Voltage	Approx. 0.95
Release current	Approx. 0.95

Times

Pickup time	Approx. 55 ms + OOT[1] at 50 Hz Approx. 45 ms + OOT at 60 Hz
Dropout time	Approx. 55 ms + OOT at 50 Hz Approx. 45 ms + OOT at 60 Hz

Tolerances

Current I_1	1 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Voltage	0.5 % of the setting value or 0.05 V
Power Q	0.5 % S_{rated} ± 3 % of the setting value (S_{rated}: rated apparent power)
Time delays	1 % of the setting value or 10 ms
Reclosure time delay	1 % of the setting value or 10 ms

Frequency Operating Range

$0.9 \le f/f_{rated} \le 1.1$	According to specified tolerances
$10\ Hz \le f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \le 80\ Hz$	Slightly expanded tolerances

[1] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

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f < 10 Hz f > 80 Hz	Active

11.39 Fault Locator

Setting Values

You can find the following settings in the line data of the Line protection function group: • Reactance per unit length of the line per kilometer or per mile • Line length for the correct output of the fault distance as a percentage of the line length • Residual compensation factors in the setting format Kr and Kx or K0 and angle (K0)	
Parallel-line compensation (optional)	For connection or disconnection
Consideration of the load current in the case of 1-phase ground faults	Correction of the x value, for connection and disconnection

Fault Distance

Output of the fault distance (line length)	In Ω primary In km, miles or in percent. [13]

Tolerances

Measuring tolerances during sinusoidal measurands and fault duration > 25 ms at 60 Hz or > 30 ms at 50 Hz	1.5 % from fault location at $V_k/V_{rated} \geq 0.01$ and one of the following scenarios: • Metal fault • Non-metal fault during single-side infeed without load

[13] The output of the fault distance in km, miles and percent presupposes a homogeneous line.

11.40 Overfrequency Protection

Setting Values

Pickup values f>	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f>	Angle-difference method	
	50 Hz	Approx. 70 ms + OOT [14]
	60 Hz	Approx. 60 ms + OOT
	Filtering method	
	50 Hz	Approx. 75 ms + OOT
	60 Hz	Approx. 75 ms + OOT
Dropout times f>	60 ms to 80 ms	

Dropout

The larger dropout differential (= | pickup value − dropout threshold |) of the following 2 criteria is used:

Dropout differential derived from the Dropout ratio parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle-difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f>	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f>)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

[14] 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

11.41 Underfrequency Protection

Setting Values

Pickup values f<	40.00 Hz to 70.00 Hz	Increments of 0.01 Hz
Dropout differential	20 mHz to 2 000 mHz	Increments of 10 mHz
Time delay T	0.00 s to 600.00 s	Increments of 0.01 s
Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V

Times

Pickup times f<	Angle-difference method	
	50 Hz	Approx. 70 ms + OOT [15]
	60 Hz	Approx. 60 ms + OOT
	Filtering method	
	50 Hz	Approx. 75 ms + OOT
	60 Hz	Approx. 75 ms + OOT
Dropout times f<	60 ms to 80 ms	

Dropout

The larger dropout differential (= | pickup value − dropout threshold |) of the following two criteria is used:

Dropout differential derived from the Dropout ratio parameter If this parameter is not available, a dropout ratio of 95 % applies to the overvoltage protection and a dropout ratio of 105 % applies to the undervoltage protection.	
Minimum absolute dropout differential	150 mV sec.

Operating Ranges

Voltage range	5 V to 230 V (phase-phase)	
Frequency range	Angle-difference method	10 Hz to 80 Hz
	Filtering method	25 Hz to 80 Hz

Tolerances

Frequency f<	
f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz	± 5 mHz at V = V_{rated}
f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz	± 10 mHz at V = V_{rated}
Time delay T(f<)	1 % of the setting value or 10 ms
Minimum voltage	1 % of the setting value or 0.5 V

[15] 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

11.42 Rate of Frequency Change Protection

Setting Values for the Function

Minimum voltage	3.000 V to 175.000 V	Increments of 0.001 V
Measuring window	2 periods to 5 periods	Increments of 1 period

Setting Values for Stage Types

Threshold	0.1 Hz/s to 20.0 Hz/s	Increments of 0.1 Hz/s
Dropout differential	0.02 Hz/s to 0.99 Hz/s	Increments of 0.01 Hz/s
Operate delay	0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value − dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio If this parameter is not available, a dropout ratio of 95 % applies for the overvoltage and of 105 % for the undervoltage functionality.	
Minimum absolute dropout differential	150 mV sec.

Times

Pickup time	Approx. 165 ms to 225 ms (depends on measuring window length)
Dropout time	Approx. 165 ms to 225 ms (depends on measuring window length)

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
10 Hz ≤ f < 0.9 f_{rated} 1.1 f_{rated} < f ≤ 80 Hz	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Threshold, measuring window > 3 periods	Approx. 3 % or 0.06 Hz/s
Threshold, measuring window < 3 periods	Approx. 5 % or 0.06 Hz/s
Minimum voltage	1 % of the setting value or 0.5 V
Time delays	1 % of the setting value or 10 ms

Functional Measured Value

Value	Description
df/dt	Calculated rate of frequency change

11.43 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

11.44 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	0.030 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.150 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	0.030 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.

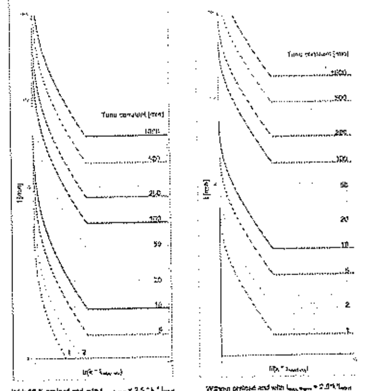
Tolerances

No filter applied (1 1 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	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 $k \cdot I_{rated}$	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[18] (33 % harmonics, in relation to the fundamental component)		
With reference to $k \cdot I_{rated}$	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[19]
	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[20]
	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[20]
With reference to the operate time	Up to 50th harmonic	3 % or 1 s for $I/(k \cdot I_{rated}) > 1.25$, 3 % class acc. to IEC 60255-8

Operate Curve

Operate curve	$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1}$	
Where	t	Operate time
	τ_{th}	Time constant
	I	Current load current
	$I_{preload}$	Preload current
	k	Setting factor according to VDE 0435 Part 3011 or IEC 60255-8 (K factor)
	$I_{rated,obj}$	Rated current of the protected object

[18] In case that the filter response exactly matches the user-defined gain factor.
[19] In case that the user-defined gain factor is set below 1. The tolerance is increased if the gain factor is larger.
[20] In case that the user-defined gain factor is set below 2. The tolerance is increased if the gain factor is larger.



With 60 % preload and with $I_{preload} = 2.5 \cdot k \cdot I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - \left(\frac{I_{preload}}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \text{ [min]}$$

Without preload and with $I_{preload} = 2.5 \cdot k \cdot I_{rated}$

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1} \text{ [min]}$$

Figure 11-24 Operate Curve of Overload Protection

11.45 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

11.46 Temperature Supervision

Setting Values

Pickup value	-50 °C to 250 °C -58 °F to 482 °F	Increments of 1°C Increments of 1°F
Time delay	0 s to 60 s or ∞	Increments of 1 s

Dropout Conditions

Dropout differential	3 °C or 5 °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

11.47 Hotspot Calculation

Setting Values

Emerg. start T overtravel		0 s to 15 000 s	Increments of 1 s
HST Warning Threshold	°C	80 °C to 140 °C	Increments of 1 °C
	°F	176 °F to 284 °F	Increments of 1 °F
HST Alarm Threshold	°C	80 °C to 140 °C	Increments of 1 °C
	°F	176 °F to 284 °F	Increments of 1 °F
Aging Warning Threshold		0.125 to 128.000	Increments of 0.001
Aging Alarm Threshold		0.125 to 128.000	Increments of 0.001
Turn time constant		0 min to 30 min	Increments of 1 min

IEC 60076-7

y Turn exponent	1.6 to 2.0	Increments of 0.1
Temperature gradient	20 to 50	Increments of 1
Factor k21	1.0 to 5.0	Increments of 0.1
Factor k22	1.0 to 5.0	Increments of 0.1
Oil time constant	50 min to 500 min	Increments of 1 min

IEEE C57.91 2011

m Turn exponent	0.8 to 1.0	Increments of 0.1
Temperature gradient	20 to 50	Increments of 1

Functional Measured Values

Measured Value	Description
(_:13531:307) Tmp.A	Hotspot temperature for phase A in °C or °F (depending on the setting)
(_:13531:308) Tmp.B	Hotspot temperature for phase B in °C or °F (depending on the setting)
(_:13531:309) Tmp.C	Hotspot temperature for phase C in °C or °F (depending on the setting)
(_:13531:310) TmpMx	Hotspot temperature for the 3 phases in °C or °F (depending on the setting)
(_:13531:311) AgRate	Relative aging rate
(_:13531:309) ResWarn	Load margin until warning indication in percent
(_:13531:306) ResAlm	Load margin until alarm indication in percent

Frequency Operating Range

Frequency tracking	10 Hz to 80 Hz

Measured Temperatures

Temperature unit of the measurement	°C or °F
Resolution	1 °C or 1 °F
Tolerance	±0.5 % of the measured value or ±1 K

Dropout Ratios

Alarm threshold	Approx. 0.99 of the setting value
Warning threshold	Approx. 0.99 of the setting value

Power Factor

The accuracy of the power factor calculation is a function of the accuracy of the current measurement.

Operate Time

Synchronizing the hotspot temperature is a slow process. The measuring interval is 600 ms. The operate time is a function of the oil temperature and the load increase.

11.48 Circuit-Breaker Failure Protection

Starting Conditions

For circuit-breaker failure protection	3-pole tripping internal or external[1]

Setting Values

Phase-current threshold values	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Sensitive threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Supervision time of release signal		0.06 s to 1.00 s	Increments of 0.01 s
Time delays		0.05 s to 60.00 s	Increments of 0.001 s
Supervision time of binary inputs		0.05 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Circuit-Breaker Supervision

Position supervision via circuit-breaker auxiliary contacts	
For 3-pole CB tripping	1 input each for make contact and break contact

NOTE

The circuit-breaker failure protection can also work without the circuit-breaker auxiliary contacts stated. Auxiliary contacts are required for circuit-breaker failure protection in cases where the current flow is absent or too low for tripping (for example with a transformer or a Buchholz protection).

[1] Via binary inputs

Times

Pickup time, in the case of an internal start Pickup time, in the case of an external start	< 1 ms < 5 ms
Typical dropout time	< 15 ms
Dropout time via circuit-breaker auxiliary contact criterion	< 5 ms

Frequency Operating Range

0.9 ≤ 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

Threshold values, dropout thresholds	2 % of the setting value or 1 % of the rated current
Times	1 % of the setting value or 10 ms

11.49 Circuit-Breaker Restrike Protection

Setting Values

Threshold value	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Monitoring duration		1.00 s to 600.00 s	Increments of 0.01 s
Position recognition delay		0.00 s to 60.00 s	Increments of 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments of 0.01 s
Trip delay time		0.05 s to 60.00 s	Increments of 0.01 s
Restrike delay time		0.00 s to 60.00 s	Increments of 0.01 s
Minimum operate (trip) time		0.00 s to 60.00 s	Increments of 0.01 s

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Times

Operate time with time delay = 0 ms	Approx. 25 ms + OOT at 50 Hz Approx. 22 ms + OOT at 60 Hz
Dropout time	Approx. 25 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

Threshold	2 % of the setting value or 5 mA (I_{rated} = 1 A) or 25 mA (I_{rated} = 5 A)
Time delays	1 % of the setting value or 10 ms

11.50 Arc Protection

Setting Values

Threshold I>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold 3I0>	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
External trip initiation		yes no	
Operating mode		Light only Current and light	
Sensor		Point sensor Line sensor Custom	
Threshold Light		-28.00 dB to 0.00 dB	Increments of 0.01
Channel		Possible settings, application dependent	

Dropout

The faster 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[2]
Shortest operate time Operating mode = Current and light	Approx. 4.0 ms + OOT at 50 Hz Approx. 3.8 ms + OOT at 60 Hz

[2] OOT (Output Operating Time) Additional delay of the output medium used, for example, for a fast relay, see Chapter 11.1.4 Relay Outputs

11.51 Inrush-Current Detection

Setting Values

Operating-range limit I_{max}	1 A @ 50 and 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Component of 2nd harmonic		10 % to 45 %	Increments of 1 %
Duration of the crossblock function		0.03 s to 200.00 s	Increments of 0.01 s

Times

Pickup times	Approx. 29 ms

Dropout Ratios

Harmonic: $I_{2nd\ harm}/I_{1st\ harm}$	0.95

Dropout

The greater dropout differential (= | pickup value - dropout value |) of the following 2 criteria applies:

Dropout differential derived from the parameter Dropout ratio	
If this parameter is not available, a dropout ratio of 95 % applies for overcurrent and of 105 % for undercurrent functionality.	
Minimum absolute dropout differential	
Protection-class current transformer	15 mA sec. (I_{rated} = 1 A) or 75 mA sec. (I_{rated} = 5 A)
Instrument current transformer	0.5 mA sec. (I_{rated} = 1 A) or 2.5 mA sec. (I_{rated} = 5 A)

Frequency Operating Range

0.9 ≤ 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

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

11.52 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 $0.8 \leq V_{aux}/V_{AuxRated} \leq 1.15$	≤ 1 %
Frequency in the range $0.95 \leq f/f_{rated} \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % of 3rd harmonics - Up to 10 % of 5th harmonics	≤ 1 % ≤ 1 %

[1] OOT (Output Operating Time) additional delay of the output medium used, see Chapter 11.1.4 Relay Outputs

11.53 Reverse-Power Protection

Setting Values

Reverse power $P_{reverse}$ (p.u.)	-0.30 % to -30.00 %	Increments of 0.01 %
Angle correction	-10.00° to 10.00°	Increments of 0.01°
Minimum voltage V1	0.300 V to 60.000 V	Increments of 0.001 V
Tripping delay	0.00 s to 60.00 s	0.00 s to 60.00 s
Tripping delay with quick stop	0.00 s to 60.00 s	0.00 s to 60.00 s
Dropout delay	0.00 s to 60.00 s	Increments of 0.01 s
Dropout ratio	0.40 to 0.99	Increments of 0.01

Times

Pickup times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz
Dropout times	Approx. 360 ms at f = 50 Hz Approx. 300 ms at f = 60 Hz

Frequency Operating Range

$0.9 \leq f/f_{rated} \leq 1.1$	According to specified tolerances
$10\ Hz \leq f < 0.9\ f_{rated}$ $1.1\ f_{rated} < f \leq 80\ Hz$	Slightly expanded tolerances
f < 10 Hz f > 80 Hz	Inactive

Tolerances

Reverse power	0.15 % S_{rated} or 5 % of the setting value when Q < 0.5 S_{rated}
Time delays	1 % or 10 ms

11.54 Current-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[1] at 50 Hz Approx. 8 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	Inactive

Tolerances

Currents	3 % of setting value or 10 mA (I_{rated} = 1 A) or 50 mA (I_{rated} = 5 A), (f_{rated} ± 10 %) for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[1] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

11.55 Voltage-Jump Detection

Times

Pickup time	Approx. 10 ms + OOT[1] at 50 Hz Approx. 8 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	Inactive

Tolerances

Voltages	2 % of the setting value or 0.100 V for amplitude changes of sinusoidal measurands
Pulse time	1 % of the setting value or 10 ms

[1] OOT (Output Operating Time) additional delay of the output medium used, for example 5 ms with fast relays

11.56 Synchronization Function

Operating Modes

Synchrocheck
Switching synchronous systems
Switching asynchronous systems
De-energized switching
Direct closing command

Setting Values

Supervision/Delay times:		
Max. Duration of synchronization process	0.00 s to 3 600.00 s or ∞ (ineffective)	Increments of 0.01 s
Supervision time de-energized switching	0.00 s to 60.00 s	Increments of 0.01 s
Closure delay	0.00 s to 60.00 s	Increments of 0.01 s
Voltage threshold values:		
Upper voltage limit V_{max}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
Lower voltage limit V_{min}	0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V
V<, for off-circuit conditions V>, for voltage present	0.300 V to 170.000 V (phase to phase) 0.300 V to 340.000 V (phase-to-phase)	Increments of 0.001 V Increments of 0.001 V
Differential values, changeover thresholds asynchronous/synchronous:		
Voltage differences V2 > V1; V2 < V1	0.000 V to 170.000 V	Increments of 0.001 V
Frequency difference f2 > f1; f2 < f1	0.000 Hz to 2.000 Hz (synchronous) 0.050 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

Tolerance of the voltage settings	2 % of the pickup value or 1 V
Voltage difference V2>V1; V2<V1	1 V
Frequency difference f2>f1; f2<f1	10 mHz
Angular difference α2>α1; α2<α1	1°
Tolerance of all time settings	10 ms
Max. phase displacement angle	5° for Δf ≤ 1 Hz 10° for Δf > 1 Hz

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11.57 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	0 s to 100 s	Increments of 1 s
T2 delay	0 s to 100 s	Increments of 1 s
Fast step down limit	0.0 % to 50.0 %	Increments of 0.1 %
Fast step down T delay	0.0 s to 10.0 s	Increments of 0.1 s
Fast step up limit	-50.0 % to 0.0 %	Increments of 0.1 %
Fast step up T delay	0.0 s to 10.0 s	Increments of 0.1 s
Function monitoring	1 min to 120 min	Increments of 1 min
Line compensation LDC-Z		
Target voltage rising	0.0 % to 20.0 %	Increments of 0.1 %
Max load current	0.0 % to 500.0 %	Increments of 0.1 %
Line compensation LDC-X and R		
R line	0.0 Ω to 30.0 Ω	Increments of 0.1 Ω
X line	-30.0 Ω to 30.0 Ω	Increments of 0.1 Ω
Limiting values		
Vmin threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Vmin time delay	0 s to 20 s	Increments of 1 s
Vmax threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
Vmax time delay	0 s to 20 s	Increments of 1 s
Blockings		
V< Threshold	40.00 kV to 1 360.00 kV	Increments of 0.01 kV
V< Time delay	0 s to 20 s	Increments of 1 s
I> Threshold	10 % to 500 %	Increments of 1 %
I> Time delay	0 s to 20 s	Increments of 1 s
I< Threshold	3 % to 150 %	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

Measured Value	Description	Primary	Secondary	% Referenced to
V tar. w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

Measured Values Grid Coupling Transformer

Measured Value	Description	Primary	Secondary	% Referenced to
Vact. w1	Actual voltage of winding 1	kV	V	Target voltage of the primary system referenced to the rated voltage
Vact. w2	Actual voltage of winding 2	kV	V	Target voltage of the primary system referenced to the rated voltage
ΔV act.	Voltage difference between the target voltage and the actual voltage	kV	V	Voltage difference referenced to the rated voltage of the controlled winding
I load w1	Load current of winding 1	A	A	Load current referenced to the rated current of winding 1
I load w2	Load current of winding 2	A	A	Load current referenced to the rated current of winding 2
Vmax 1	Maximum voltage of winding 1	kV	V	Maximum voltage of winding 1 referenced to the rated voltage of winding 1
Vmax 2	Maximum voltage of winding 2	kV	V	Maximum voltage of winding 2 referenced to the rated voltage of winding 2
Vmin 1	Minimum voltage of winding 1	kV	V	Minimum voltage of winding 1 referenced to rated voltage of winding 1
Vmin 2	Minimum voltage of winding 2	kV	V	Minimum voltage of winding 2 referenced to rated voltage of winding 2
V tar. w1	Target voltage of winding 1	kV	V	Target voltage of winding 1 referenced to the rated voltage of winding 1
V tar. w2	Target voltage of winding 2	kV	V	Target voltage of winding 2 referenced to the rated voltage of winding 2

Dropout Ratio

Threshold of the voltage limit	About 0.99 of the setting value
Threshold of the current limit	About 0.99 of the setting value

11.58 Current-Balance Supervision

Setting Values

Release threshold	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	1 A @ 50 Irated		
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	5 A @ 50 Irated		
	1 A @ 1.6 Irated	0.030 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Threshold value min/max		0.10 to 0.95	Increments of 0.01
Tripping delay		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overcurrent dropout ratio	About 0.97
Undercurrent dropout ratio	About 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

11.59 Voltage-Balance Supervision

Setting Values

Release threshold value	0.300 V to 170.000 V	Increments of 0.001 V
Threshold value min/max	0.58 to 0.95	Increments of 0.01
Tripping delay	0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Overvoltage dropout ratio	Approx. 0.97
Undervoltage dropout ratio	Approx. 1.05

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

11.60 Current-Sum Supervision

Setting Values

Slope of the characteristic curve		0.00 to 0.95	Increments of 0.01
Threshold	1 A @ 50 and 100 Irated	0.030 A to 10.000 A	Increments of 0.001 A
	5 A @ 50 and 100 Irated	0.15 A to 50.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A
Tripping delay		0.00 s to 100.00 s	Increments of 0.01 s

Dropout Ratio

Dropout ratio	About 0.97

Times

Tripping time	Approx. 500 ms
Dropout time	Approx. 500 ms

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11.61 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

11.62 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

11.63 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

11.64 Trip-Circuit Supervision

Setting Values

Number of monitored circuits per circuit-breaker function group	1 to 3	
Operating mode per circuit	With 1 binary input With 2 binary inputs	
Pickup and dropout time	About 1 s to 2 s	
Adjustable indication delay with 1 binary input	1.00 s to 600.00 s	Increments of 0.01 s
Adjustable indication delay with 2 binary inputs	1.00 s to 600.00 s	Increments of 0.01 s

11.65 Protection Interface and Protection Topology

Setting Values

Mode	On Off	
PPS synchronization	Telegr. and PPS Telegr. or PPS PPS synchronization off	
Blocking of the unbalanced runtimes	Yes No	
Maximum signal runtime threshold	0.1 ms to 30.0 ms	Increments of 0.1 ms
Maximum runtime difference	0.000 ms to 3.000 ms	Increments of 0.001 ms
Failure indication after	0.05 s to 2.00 s	Increments of 0.01 s
Failure indication after	0.0 s to 6.0 s	Increments of 0.1 s
Max. error rate/h	0.000 % to 100.000 %	Increments of 0.001 %
Max. error rate/min	0.000 % to 100.000 %	Increments of 0.001 %
PPS failure indication after	0.5 s to 60.0 s	Increments of 0.1 s

Transmission Rate

Direct connection:	
Transmission rate	2048 kbit/s
Connection via communication networks:	
Supported network interfaces	G703.1 with 64 kBit/s G703-T1 with 1.455 MBit/s G703-E1 with 2.048 MBit/s X.21 with 64 kBit/s or 128 kBit/s or 512 kBit/s Pilot wires with 128 kbit/s
Transmission rate	64 kBit/s at G703.1 1.455 MBit/s at G703-T1 2.048 MBit/s at G703-E1 512 kBit/s or 128 kBit/s or 64 kBit/s at X.21 128 kBit/s for pilot wires

Transmission Times

Priority 1		
Response time, total approx.		
For 2 ends	Minimum	8 ms
	Typical	10 ms
For 3 ends	Minimum	10 ms
	Typical	14 ms
For 6 ends	Minimum	15 ms
	Typical	18 ms
Dropout times, total approx.		
For 2 ends	Typical	20 ms
For 3 ends	Typical	20 ms
For 6 ends	Typical	26 ms

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	25 ms
For 6 ends	Typical	30 ms

Priority 3[17]		
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

17) [illegible]

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11.66 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)[47]
	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	0 to 120 (steps of 15)

[47] If provided

11.67 Phasor Measurement Unit

Accuracy

As per IEEE Std C37.118.1a-2014

Synchrophasor Standard

IEEE Std C37.118.1-2011

11.68 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).

11.69 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[48] 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[49] at 50 Hz
	Approx. 9 ms + OOT at 60 Hz

Use in other function group types	
Pickup time	Approx. 20 ms + OOT[50] 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

[48] OOT (Output Operating Time) Additional delay of the output medium used, see chapter 11.1.4 Relay Outputs
[49] 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
[50] 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

11.70 Voltage-Transformer Circuit Breaker

Setting Values

Response time	0.000 s to 0.030 s	Increments of 0.001 s

ВЯРНО С ОРИГИНАЛА

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11.71 Operational Measured Values and Statistical Values

The following applies to the tolerances of currents and voltages:

- The values apply both to the RMS values and the absolute value and phase angle of the fundamental components.
- The values were determined for pure sinusoidal signals – without harmonics.

Voltages

V_A, V_B, V_C Voltage range	V secondary < 200 V secondary
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC (0.8 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
V_{AB}, V_{BC}, V_{CA} Voltage range	V secondary < 200 V
Secondary rated voltage Measuring range Frequency range	100 V to 125 V AC (0.8 to 2) · V_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Instrument Transformers

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated current Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Protection-Class Current Transformer

I_A, I_B, I_C, $3I_0$ Current range	A secondary < 100 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A 0.1 to 25 A 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.2 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Currents, Sensitive Ground-Current Transformer

$3I_0$ Current range	A secondary < 1.6 I_{rated}
Rated currents Measuring range Frequency range	1 A, 5 A (0.1 to 1.6) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.15 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range

Phase Angle

ΦV	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦV	0.2 ° at rated voltage
ΦI	°
Frequency range	47.5 Hz to 52.5 Hz at f_{rated} = 50 Hz 57.5 Hz to 62.5 Hz at f_{rated} = 60 Hz
Tolerance ΦI	0.2 ° at rated current

Power Values

Active power P	W secondary
Measuring range Voltage range Current range Frequency range	|cosφ| ≥ 0.01 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz

Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range
Reactive power Q	var secondary
Measuring range Voltage range Current range Frequency range	|cosφ| ≤ 0.984 (0.8 to 1.2) · V_{rated} (0.1 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	1.0 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	1.5 % of the measured value in the above mentioned measuring range
Apparent power S	VA
Measuring range Voltage range Current range Frequency range	(0.01 to 2) · S_{rated} (0.8 to 1.2) · V_{rated} (0.01 to 2) · I_{rated} 49 Hz to 51 Hz at f_{rated} = 50 Hz 59 Hz to 61 Hz at f_{rated} = 60 Hz
Tolerance	0.3 % of the measured value in the above mentioned measuring range
Frequency range (expanded)	40 Hz to 60 Hz at f_{rated} = 50 Hz 50 Hz to 70 Hz at f_{rated} = 60 Hz
Tolerance	0.5 % of the measured value in the above mentioned measuring range

Frequency

Frequency f	Hz
Range	f_{rated} - 0.20 Hz < f_{rated} + 0.20 Hz
Tolerance	± 5 mHz in the V_{rated} range
Range	f_{rated} - 3.00 Hz < f_{rated} + 3.00 Hz
Tolerance	± 10 mHz in the V_{rated} range
Frequency range (expanded)	25 Hz to 80 Hz; operational measured values 10 Hz to 80 Hz; functional measured values, system frequency
Tolerance	20 mHz in the range f_{rated} ± 10 % for rated values

Statistical Values of the Device

Device operating hours	h
Range	0 to 9 999 999 h
Tolerance	1 h

Statistical Values of the Circuit Breaker

Op.cnt. (operation counter)	
Range	0 to 999 999 999
Tolerance	None
ΣI Off (sum of the primary currents switched off)	A, kA, MA, GA, TA, PA primary
Range	0 to 9.2 e15
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

11.72 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 %

11.73 CFC

Typical response times and maximum number of ticks at the CFC task levels:

Task Level	Time (in ms)	Ticks CP200	Ticks CP300
Fast Event-Triggered	<1	500	1000
Event-Triggered	<10	3176	12 073
Interlocking	<10	24 716 in total	112 996 in total
Measurement	250		

The times describe the response time of a typical CFC chart at the respective task level. The maximum number of ticks applies to a typical load for the device based on the application template **3-Winding Transformer (DIFF, Protection, CBFP, EDS, DIS)**.

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:

$$T_{total} = 5 \cdot n_{inp} + 5 \cdot n_{outp} + T_{TLev} + \Sigma T_{int} + \Sigma T_{block}$$

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 11-5 Ticks of the Individual CFC Blocks

Element	Ticks
ABS_D	2.0
ABS_R	1.5
ACOS_R	6.9
ADD_D4	3.4
ADD_R4	3.3
ADD_XMV	6.4
ALARM	1.8
AND_SPS	1.1
AND10	2.0
APC_DEF	1.2
APC_EXE	3.0
APC_INFO	3.9
ASIN_R	1.3
ATAN_R	1.2
BLINK	1.8
BOOL_FLT	2.0
BOOL_INT	[illegible]
BSC_DEF	1.1
BSC_EXE	1.1

Element	Ticks
BSC_INFO	2.2
BUILD_ACD	2.9
BUILD_ACT	2.7
BUILD_BSC	1.2
BUILD_CMV	2.7
BUILD_DEL	2.1
BUILD_DPS	1.4
BUILD_ENS	1.3
BUILD_INS	0.9
BUILD_Q	0.8
BUILD_SPS	0.6
BUILD_WYE	3.7
BUILD_XMV	2.2
BUILDC_Q	3.0
CHART_STATE	5.9
CMP_DPS	3.5
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	5.0
DINT_UINT	3.0
DIV_D	2.9
DIV_R	1.6
DIV_XMV	2.2
DPC_DEF	0.4
DPC_EXE	0.4
DPC_INFO	1.1
DPC_OUT	1.3
DPS_SPS	1.0
DRAGI_R	1.7
EQ_D	1.0
EQ_R	1.9
EXP_R	1.5
EXPT_R	2.7
F_TRGM	0.9
F_TRIG	0.8
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	1.2
HOLD_D	1.3
HOLD_R	1.0
INT_INFO	0.9
LE_D	1.1
LE_R	1.1
LIMIT_R	1.5
LIMIT_D	1.5
LN_R	3.3
LOG_R	1.2
LOOP	1.3
LT_D	0.9
LT_R	0.9
MAX_D	0.9
MAX_R	1.4
MEMORY_D	0.9
MEMORY_R	1.1
MIN_D	0.7
MIN_R	1.3
MOD_D	1.5
MUL_D4	2.5
MUL_R4	2.7
MUL_XMV	2.8
MUX_D	1.2
MUX_R	0.9
NAND10	3.5
NE_D	0.9
NE_R	0.9
NEG	1.2
NEG_SPS	0.8
NLC_LZ	2.1
NLC_XMV	4.4
NLC_ZP	1.0
NOR10	3.2
OR_DYN	1.1
OR_SPS	1.3
OR10	2.6
R_TRGM	0.4
R_TRIG	0.4
REAL_DINT	3.0
REAL_SXMV	3.0
SIN_R	0.8
SPC_DEF	0.4
SPC_EXE	0.4
SPC_INFO	0.4

Element	Ticks
SPC_OUT	0.4
SPLIT_ACD	8.4
SPLIT_ACT	1.0
SPLIT_BSC	1.3
SPLIT_CMV	2.2
SPLIT_DEL	2.0
SPLIT_DPS	1.0
SPLIT_INS	0.8
SPLIT_Q	0.7
SPLIT_SPS	0.8
SPLIT_WYE	7.6
SPLIT_XMV	7.1
SQRT_R	0.6
SUB_D	1.3
SUB_R	1.6
SUB_XMV	2.3
SUBST_B	1.0
SUBST_BQ	1.5
SUBST_D	1.5
SUBST_R	1.0
SUBST_XQ	1.4
SXMV_REAL	1.0
TAN_R	1.1
TICKS	2.2
TOF	1.0
TON	1.1
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 enhancements

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 Typographic and Symbol Conventions

The following typefaces are used to characterize parameters in the text:

Style	Parameter Name
_:XX:11	Parameter address _ stands for the address combination from function group/function 0:1, for example, stands for the address of the setting parameter
Zoom	Parameter state

The following symbols are used in drawings:

Icon	Description
_:091:1 Stage blocked	Parameter
_:901:1 Mode (off, on, test)	Parameters with setting values. The default setting is in the 1st position and displayed in italics
_:4681:2 Operate & flt.rec. blocked / Dynamic setting inf	Parameters with application-dependent setting values
4841:3 Threshold	Dynamic settings
State control (State: Off, On, Test)	State logic
Health (OK, Warning, Alarm)	Health of a function, stage, or function block
>Block stage	External binary input signal with indication number
Pickup (General, A, B, C)	External output signal with indication number and additional information
Pickup	External output signal without indication number
_:2451:300 I diff.	Measured output value

Icon	Description
Test mode	Binary input signal derived from an external output signal
	Internal input signal
Block reset 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 C	RS-Flip-Flop, SR-Flip-Flop, D-Flip-Flop
	Characteristic curve
Min-Ch	Minimum operate time

A.3 Available Protection and Control Functions in the Transformer Differential Protection Function Groups

EXAMPLE

The structure of the text and reference number is shown at 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 A-1). Only one function and one function group exist in the device. The representation of the stage is simplified.

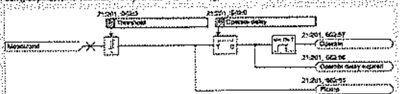

Figure A-1 Stage of the Overcurrent Protection Function, Phases (without Representation of Stage Control)

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	-

On instance numbers the following applies:

- 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; there the 2nd instance is 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	21:201:66:3
Indication	Number
Line 1:Overcurrent 3 ph 1:Definite time-overcurrent protection 2:Pickup	21:201:66:55

¹ The structure is simplified accordingly for parameters and indications with fewer hierarchy levels.

The following table offers an overview of the protection and control functions which are available in the function groups of the devices 7UT82, 7UT85, 7UT86, and 7UT87.

Table A-1 Functions in the Function Groups

ANSI	Protection Function FN	Protection Function Number in DIGSI	90 Transformer Diff.	91 Transformer Side	92 Transformer Neutral Point	93 Auto Transformer Diff.	94 Auto Transformer Auto Side	95 Auto Transformer Comp. Side	96 Auto Transformer Ground Side	97 Auto Transformer Neutral Point	86 Motor Diff.	87 Motor Side	81 Voltage 3ph	83 Voltage-Current 1ph	82 Voltage-Current 3ph	59 Generator Diff.	58 Generator Side	16 Voltage Controller	2 Line	20 Circuit Breaker
21/21N	Distance protection (3-phase, grounded)	89	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	1	
	Distance protection (isolated/resonant grounded system)	89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
21T	Impedance protection for transformers	220	-		-			-		-		-			-		1	-	1	-
24	Overexcitation protection	193	-	1	-	-	1	1	-	-	-	1	1	-	1	-	1	-	1	-
25	Synchrocheck, synchronization function	115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
27	Undervoltage protection, 3-phase	53		2	-		2	2		-		2	2		2		2		2	-
	Undervoltage protection, positive-sequence system	15	-	2	-		2	2		-		2	2		2		2	-	2	-
	Undervoltage protection, 3-phase, universal, Vx	18	-	4		-	4	4	-	-	-	4	4	-	4	-	4	-	4	-
27Q	QU protection	206	-	2	-	-	2	2	-	-	-	2	-	-	2	-	-	-	2	-
32/37	Power protection 3-phase active/reactive power	117	-	2	-		2	2		-	-	2			2		2		2	-
32R	Reverse-power protection	93	-	2	-	-	2	2	-	-	-	2	-	-	2	-	-	-	2	-
37	Undercurrent protection	191		2		-	2	2	-			2		-	2	-	2		2	
38	Temperature supervision	170	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1	-	4	-
46	Negative-sequence system overcurrent protection	30	-	2	-	-	2	2	2	-	-	2	-	-	2	-	1	-	2	-
	Unbalanced-load protection (thermal)	32	-	2	-	-	2	2	2	-	-	2	-	-	2	-	2	-	2	-
47	Overvoltage protection, negative-sequence system	8	-	2	-	-	2	2	-		-	2	2	-	2	-	2	-	2	-
	Overvoltage protection, negative-sequence system/positive-sequence system	250	-	2	-		2	2				2	2		2		2		2	-
49	Thermal overload protection, 3-phase	60	-	1	-	-	1	1	1	-	-	1		-	1	-	-	-	1	-
	Thermal overload protection, 1-phase		-	-	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-
49H	Hot spot calculation	290		2			2	2				2			2				2	
50BF	Circuit-breaker failure protection	438	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1

ANSI	Protection Function FN	Protection Function Number in DIGSI	90 Transformer Diff.	91 Transformer Side	92 Transformer Neutral Point	93 Auto Transformer Diff.	94 Auto Transformer Auto Side	95 Auto Transformer Comp. Side	96 Auto Transformer Ground Side	97 Auto Transformer Neutral Point	86 Motor Diff.	87 Motor Side	81 Voltage 3ph	83 Voltage-Current 1ph	82 Voltage-Current 3ph	59 Generator Diff.	58 Generator Side	16 Voltage Controller	2 Line	20 Circuit Breaker
50RS	Circuit-breaker restrike supervision	1509	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
50/51 TD	Overcurrent protection, phases	70		2		-	2	2	2		-	2			2	-	2	-	2	
50N/51N TD	Overcurrent protection, ground	21	-	2	-	-	2	2	2	-	-	2	-	-	2	-	-	-	2	-
50Ns/51Ns	Sensitive ground-current protection for systems with resonant-grounded or isolated neutral	187	-	2	-		2	2	2	-		2	-	2	2				2	-
50HS	Instantaneous high-current tripping	97		1		-	1	1	1			1			1	-			1	-
50N/51N TD	Overcurrent protection, 1-phase	189	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
51V	Overcurrent protection, 3-phase, voltage-dependent	205	-	2	-	-	2	2	-	-	-	2	-	-	2	-	2	-	2	-
59	Overvoltage protection, 3-phase	5	-	2		-	2	2			-	2	2		2	-	2		2	
	Overvoltage protection, positive-sequence system	6	-	2	-	-	2	2	-	-	-	2	2	-	2	-	2	-	2	-
	Overvoltage protection, 3-phase, universal, Vx	12	-	1			4	4				4	4		4		4		4	-
59N	Overvoltage protection, zero-sequence system	10	-	2	-	-	2	2	-	-	-	2	2	-	2	-	2	-	2	-
67	Directional time-overcurrent protection, phases	197	-	2			2	2	-			2	-		2	-	2	-	2	
67N	Directional time-overcurrent protection, ground	174	-	2	-		2	2		-		2	-	-	2	-	-	-	2	-
67Ns	Sensitive ground-fault detection for resonant-grounded and isolated systems incl. • V0> • cos-φ/sin-φ • Transient function • φ(V,I) • Admittance	186	-	2	-	-	2	2	-	-	-	2	-	2	2	-	-	-	2	-
	Intermittent ground-fault protection	213	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	2	-
	Directional intermittent ground fault protection	224												2	2				2	

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			Function Group FG																	
			90	91	92	93	94	95	96	97	86	87	81	83	82	59	58	16	2	20
ANSI	Protection Function FN	Protection Function Number in DIGSI	Transformer Diff.	Transformer Side	Transformer Neutral Point	Auto Transformer Diff.	Auto Transformer Auto Side	Auto Transformer Comp. Side	Auto Transformer Ground Side	Auto Transformer Neutral Point	Motor Diff.	Motor Side	Voltage 3ph	Voltage-Current 1ph	Voltage-Current 3ph	Generator Diff.	Generator Side	Voltage Controller	Line	Circuit Breaker
68	Power-swing blocking	571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
74TC	Trip-circuit supervision	444	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
79	Automatic reclosing	136	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
81O	Overfrequency protection	1	-	2	-	-	2	2	-	-	-	2	2	-	2	-	2	-	2	-
81U	Underfrequency protection	3	-	2	-	-	2	2	-	-	-	2	2	-	2	-	2	-	2	-
81R	Rate-of-frequency-change protection	195	-	2	-	-	2	2	-	-	-	2	2	-	2	-	2	-	2	-
85/21	Teleprotection scheme for distance protection	1259 129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
85/27	Weak or no infeed: Echo and tripping	133	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
85/67N	Teleprotection scheme for directional ground fault protection	1384 132	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
87G	Differential protection, generator	241	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
87L	Line differential protection for 2 line ends	82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
87M	Differential protection, motor	208	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
87 STUB	Stub-fault differential protection (for 1 1/2 circuit-breaker applications)	143	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
87T	Differential protection, transformer	169	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Differential protection for phase-angle regulating transformers (single core)	1641	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Differential protection for special transformers	1644	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Differential protection for phase-angle regulating transformers (two-core)	1647	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
87N T	Restricted ground-fault protection	1008	-	1	-	1	-	1	-	-	-	-	-	-	1	-	-	-	-	-

			Function Group FG																	
			90	91	92	93	94	95	96	97	86	87	81	83	82	59	58	16	2	20
ANSI	Protection Function FN	Protection Function Number in DIGSI	Transformer Diff.	Transformer Side	Transformer Neutral Point	Auto Transformer Diff.	Auto Transformer Auto Side	Auto Transformer Comp. Side	Auto Transformer Ground Side	Auto Transformer Neutral Point	Motor Diff.	Motor Side	Voltage 3ph	Voltage-Current 1ph	Voltage-Current 3ph	Generator Diff.	Generator Side	Voltage Controller	Line	Circuit Breaker
90 V	Two-winding transformer voltage controller	1401	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	Three-winding transformer voltage controller	1560	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	Grid-coupling transformer voltage controller	1455	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
FL	Fault locator, single-ended	667	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-
SOTF	Instantaneous tripping at switch onto fault	134	-	2	-	-	2	2	2	-	-	2	-	-	2	-	-	-	2	-
AFD	Arc protection	235	-	1	-	-	1	-	-	-	-	-	-	-	1	-	-	-	1	-
	Inrush-current detection	414	-	1	-	-	1	1	1	-	-	1	-	-	1	-	1	-	1	-
	External trip initiation	28	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9		9	

A.4 Standard Variant for 7UT82

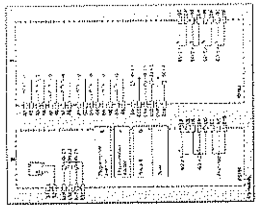


Figure A-2 Standard Variant 7UT82

A.5 Standard Variants for 7UT85

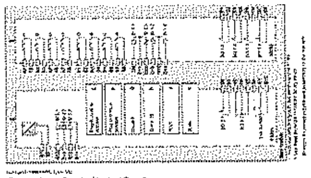


Figure A-3 Standard Variant Type 1

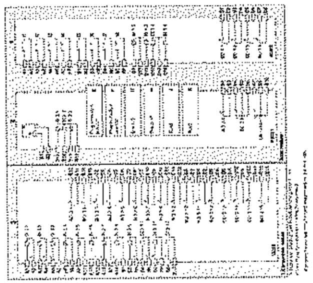


Figure A-4 Standard Variant Type 2

A.6 Standard Variants for 7UT86

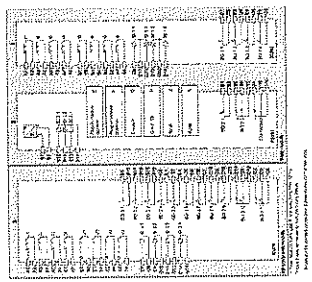


Figure A-5 Standard Variant Type 1

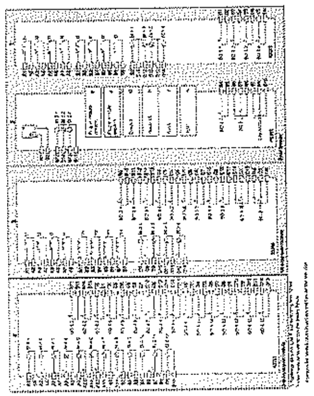


Figure A-6 Standard Variant Type 2

A.7 Standard Variants for 7UT87

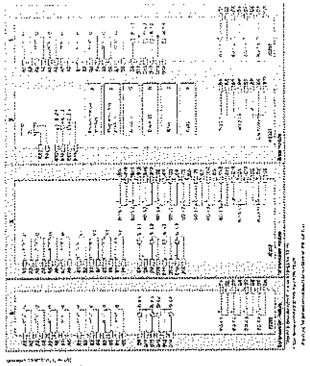


Figure A-7 Standard Variant Type 1

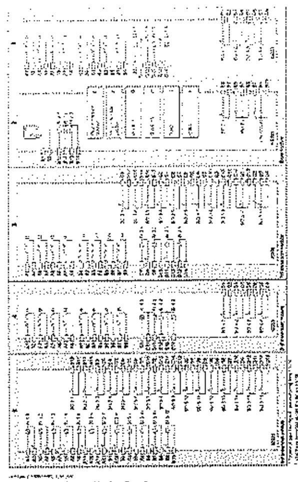


Figure A-8 Standard Variant Type 2

A.8 Requirements for Current Transformer of Transformer Differential Protection (Phase Current Transformer)

Transformer Type	Required Factor ALF'		
	Minimum	Internal Fault	External Fault
IEC 5P, IEC 10P [1] (up to 80 % remanence)	25	$\geq 0.6 \cdot \frac{I_{SCmax,int}}{I_{pr}}$	$\geq 2 \cdot \frac{I_{SCmax,ext}}{I_{pr}}$
IEC 5PR, IEC 10PR [2]	12.5	$\geq 0.4 \cdot \frac{I_{SCmax,int}}{I_{pr}}$	$\geq 1.5 \cdot \frac{I_{SCmax,ext}}{I_{pr}}$
	Required Product $K_{td} \cdot K_{SSC}$		
IEC TPX (up to 80 % remanence)	25	$\geq 0.5 \cdot \frac{I_{SCmax,int}}{I_{pr}}$	$\geq 2 \cdot \frac{I_{SCmax,ext}}{I_{pr}}$
IEC TPY	12.5	$\geq 0.4 \cdot \frac{I_{SCmax,int}}{I_{pr}}$	$\geq 1.5 \cdot \frac{I_{SCmax,ext}}{I_{pr}}$
IEC TPZ	12.5	$\geq 0.4 \cdot \frac{I_{SCmax,int}}{I_{pr}}$	$\geq 1.5 \cdot \frac{I_{SCmax,ext}}{I_{pr}}$
	Required Knee-Point Voltage E_k (Vrms)		
IEC PX (up to 80 % remanence)	$20 \cdot I_{sr} \cdot R_t$	$\geq 0.4 \cdot \frac{I_{SCmax,int}}{I_{pr}} \cdot I_{sr} \cdot R_t$	$\geq 1.6 \cdot \frac{I_{SCmax,ext}}{I_{pr}} \cdot I_{sr} \cdot R_t$
IEC PXR	$10 \cdot I_{sr} \cdot R_t$	$\geq 0.3 \cdot \frac{I_{SCmax,int}}{I_{pr}} \cdot I_{sr} \cdot R_t$	$\geq 1.3 \cdot \frac{I_{SCmax,ext}}{I_{pr}} \cdot I_{sr} \cdot R_t$
	Required Transformer Terminal Voltage V_{al} (Vrms)		
ANSI C (I_{sr} = 5 A) (up to 80 % remanence)	$25 \cdot I_{sr} \cdot R_{ba}$	$\geq 0.5 \cdot \frac{I_{SCmax,int}}{I_{pr}} \cdot I_{sr} \cdot R_{ba}$	$\geq 2 \cdot \frac{I_{SCmax,ext}}{I_{pr}} \cdot I_{sr} \cdot R_{ba}$

Remanence leads to an earlier saturation which, in general, is critical for the differential protection. For new systems, Siemens recommends anti-remanence cores in the classes 5PR, PXR and TPY. In case of the high direct-current components to be expected, Siemens recommends the class TPZ, so that an overfunction with external faults is avoided.

ALF'	Operational accuracy limit factor
ALF'	$ALF' = ALF \cdot \frac{R_{ct} + R_b}{R_{ct} + R_{ba}}$
ALF	Rated accuracy limit factor
R_{ct}	Secondary winding resistance
R_b	Ohmic rated burden
R_{ba}	Connected ohmic rated resistive burden
R_t	$(R_{ct} + R_{ba})$
I_{pr}	Primary rated current of the transformer
I_{sr}	Secondary rated current of the transformer
$I_{SCmax,int}$	Maximum internal symmetric fault current
$I_{SCmax,ext}$	Maximum external symmetric fault current
K_{td}	Transient rated dimensioning factor

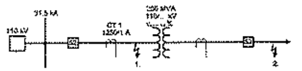
[1] Fault angle is not specified in IEC 61869-2; therefore, the Class 10P for the differential protection is not recommended.
[2] Fault angle is not specified in IEC 61869-2; therefore, the Class 10PR for the differential protection is not recommended.

K_{SSC}	Factor of the symmetric rated short-circuit current = I_{psc}/I_{pr}
E_k	Knee-point voltage
V_r	Rated terminal voltage with 20-fold rated current and rated burden R_b
V_{al}	Current terminal voltage with 20-fold rated current and current burden R_{ba}

NOTE

When using distance or line differential protection functions in the transformer differential protection, the current-transformer requirements of the line protection are to be considered. You can find these in the Line protection manual (C53000-G5040-C010).

Example



Layout of Current Transformer 1 (Transf. 1):

$I_{SC,max}$ = 31.5 kA

Transformer rated current $I_{N,T}$ = 200 000 kVA/(√3 · 110 kV) = 1050 A (110 kV side)

$I_{SC,ext}$ = $I_{N,T}$ · 100 %/u_k = 1050 A · 100 %/14 % = 7498 A (110 kV side)

$K_{SSC,int}$ = 31 500 A/1250 A = 25.2, $K_{SSC,ext}$ = 7498 A/1250 A = 6.0

a) IEC class 5P

1st internal fault: ALF' = 0.5 · 31 500 A/1250 A = 12.6

2nd external fault: ALF' = 2 · 7498 A/1250 A = 12 → but minimum 25

Result:

Operating accuracy limiting factor of ≥ 25, for example: 5P30, R_b = S_r/I_{sr}^2 ≥ connected burden R_{ba} (for example: S_r = 2.5 VA or 5 VA)

b) IEC class TPY

1st internal fault: $K_{td} \cdot K_{SSC}$ = 0.4 · 31 500 A/1250 A = 10.08

2nd external fault: $K_{td} \cdot K_{SSC}$ = 1.5 · 7498 A/1250 A = 9 → but minimum 12.5

Result:

The product $K_{td} \cdot K_{SSC}$ must be ≥ 12.5, for example: K_{SSC} = $K_{SSC(TPY)}$ = 25 and K_{td} = 0.5

Rated burden R_b ≥ connected burden R_{ba} (for example, R_b = 2.5 Ω or 5 Ω)

c) IEC class PX, assumptions R_{ct} = 4.3 Ω, R_{ba} = 1.5 Ω

1st internal fault:

$$E_k \geq 0.4 \cdot \frac{I_{SCmax,int}}{I_{pr}} \cdot I_{sr} \cdot R_t \geq 0.4 \cdot \frac{31500\ A}{1250\ A} \cdot 1\ A \cdot (4.3\ \Omega + 1.5\ \Omega) \geq 58.5\ Vrms$$

2nd external fault:

$$E_k \geq 1.6 \cdot \frac{I_{SCmax,ext}}{I_{pr}} \cdot I_{sr} \cdot R_t \geq 1.6 \cdot \frac{7498\ A}{1250\ A} \cdot 1\ A \cdot (4.3\ \Omega + 1.5\ \Omega) \geq 55.7\ Vrms$$

but minimum $E_k = 20 \cdot I_{sr} \cdot R_t = 20 \cdot 1\ A \cdot (4.3\ \Omega + 1.5\ \Omega) = 116$ Vrms

Result:

The PX transformer must have a knee-point voltage of ≥ 116 Vrms, for example, E_k = 150 Vrms.

A.9 Requirements for Current Transformer of Generator Differential Protection (Phase Current Transformer)

Transformer Type	Required Factor ALF'	
	Minimum	External Fault
IEC 5P, IEC 10P [1] (up to 80 % remanence)	30	$\geq 4 \frac{I_{SC,max}}{I_{pr}}$
IEC 5PR, IEC 10PR [2]	25	$\geq 3 \frac{I_{SC,max}}{I_{pr}}$
	Require Product $K_{td} \cdot K_{SSC}$	
IEC TPY	25	$\geq 3 \frac{I_{SC,max}}{I_{pr}}$
IEC TPZ	25	$\geq 3 \frac{I_{SC,max}}{I_{pr}}$
	Required Knee-Point Voltage E_k (Vrms)	
IEC PX (up to 80 % remanence)	$25 \cdot I_{sr} \cdot R_t$	$\geq 3 \frac{I_{SC,max}}{I_{pr}} I_{sr} R_t$
	Required Transformer Terminal Voltage V_{al} (Vrms)	
ANSI C (I_{sr} = 5 A) (up to 80 % remanence)	$30 \cdot I_{sr} \cdot R_{ba}$	$\geq 4 \frac{I_{SC,max}}{I_{pr}} I_{sr} R_{ba}$

Remanence leads to an earlier saturation which, in general, is critical for the differential protection. For new systems, Siemens recommends anti-remanence cores in the classes 5PR and TPY. In case of the high direct-current components to be expected, Siemens recommends the class TPZ, so that an overfunction with external faults is avoided. Siemens recommends TPZ for large generators (for example, > 500 MVA).

NOTE

In comparison to transformer applications, the current transformer setup is sufficient for observation of external faults.

ALF'	Operational accuracy limit factor
ALF'	$ALF' = ALF \cdot \frac{R_{ct} + R_b}{R_{ct} + R_{ba}}$
ALF	Rated accuracy limit factor
R_{ct}	Secondary winding resistance
R_b	Ohmic rated burden
R_{ba}	Connected ohmic rated resistive burden
R_t	$(R_{ct} + R_{ba})$
I_{pr}	Primary rated current of the transformer
I_{sr}	Secondary rated current of the transformer
$I_{SC,max}$	Maximum internal symmetric fault current

[1] Fault angle is not specified in IEC 61869-2; therefore, the Class 10P for the differential protection is not recommended.
[2] Fault angle is not specified in IEC 61869-2; therefore, the Class 10PR for the differential protection is not recommended.

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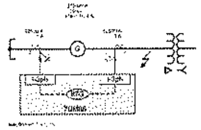
$I_{scc\,max}$	Maximum external symmetrical fault current
K_{td}	Transient rated dimensioning factor
K_{ssc}	Factor of the symmetric rated short circuit current = I_{psc}/I_{pr}
E_k	Knee-point voltage
V_s	Rated terminal voltage with 20-fold rated current and rated burden R_b
V_a	Current terminal voltage with 20-fold rated current and current burden R_{ba}

Example



Layout of Current Transformer 1:

Generator rated current $I_{N,G}$ = 370 MVA/(√3 · 20 kV) = 10681 A

$$I_{SC\,max} = \frac{c \cdot S_{N,G}}{\sqrt{3} \cdot V_{N,G} \cdot x_d''} = \frac{1.1 \cdot 370\ MVA}{\sqrt{3} \cdot 20\ kV \cdot 0.164} = 71641\ A$$

$$K_{ssc} = \frac{I_{sc\,max}}{I_{pr}} = \frac{71641\ A}{12500\ A} = 5.73$$

a) IEC class 5P

ALF = 4 · 71641 A/12500 A = 22.92 but minimum 30

Result:

Operating accuracy limiting factor of ≥ 30, for example: 5P30, R_b = S_r/I_{sr}^2 ≥ connected burden R_{ba} (for example: S_r = 2.5 VA or 5 VA)

b) IEC class TPY

$K_{td} \cdot K_{ssc}$ = 3 · 5.73 = 17.19 → minimum but 25

Result:

The product $K_{td} \cdot K_{ssc}$ must be ≥ 25.

Rated burden R_b ≥ connected burden R_{ba} (for example, R_b = 2.5 Ω or 5 Ω)

NOTE

Close a TPZ transformer for compliance of an angle error with rated burden. Due to larger angle error, do not connect the function reverse-power protection to this transformer. Use a separate instrument transformer (see chapter 6.50.1 Overview of Functions).

c) IEC class PX, assumption: R_{ct} = 4.2 Ω, R_{ba} = 1.5 Ω

$$E_k \geq 3 \frac{I_{sc\,max}}{I_{pr}} I_{sr} R_t = 3 \frac{71641\ A}{12500\ A} 1\ A (4.2\ Ω + 1.5\ Ω) = 98.72\ Veff$$

but minimum E_k = 25 · I_{sr} · R = 25 · 1 A · (4.2 Ω + 1.5 Ω) = 145 Vrms

Result:

The PX transformer must have a knee-point voltage of ≥ 145 Vrms, for example: E_k = 180 Vrms.

d) ANSI C, assumption: I_{sr} = 5 A, R_{ba} = 1.1 Ω

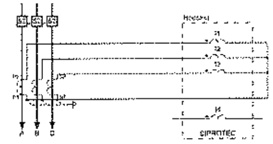
$$V_a = 4 \frac{I_{sc\,max}}{I_{pr}} I_{sr} R_{ba} = 4 \frac{71641\ A}{12500\ A} 5\ A \cdot 1.1\ Ω = 126.1\ Veff$$

but minimum V_a = 30 · I_{sr} · R_{ba} = 30 · 5 A · 1.1 Ω = 165 Vrms

Result:

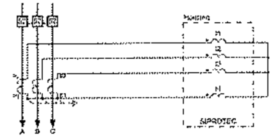
The ANSI C transformer must have a terminal voltage of ≥ 165 Vrms, for example: V_s = 200 Vrms which leads to selection of a transformer class of C200.

A.10 Connection Examples for Current Transformers



Current transformer 3-phase connection + 3-phase

Figure A.9 Connection to a 3-Wire Current Transformer (Residual Current to be Calculated)

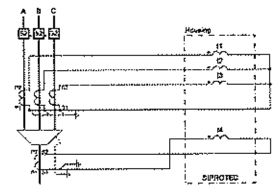


Current transformer 3-phase connection + 3-phase + IN

Figure A.10 Connection to a 3-Wire Current Transformer and Measured Zero Sequence Current (Current in Common Return Path)

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 (I_N)!

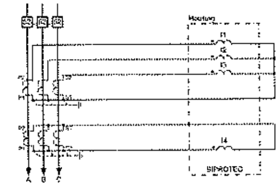


Current transformer 3-phase, connection + 3-phase + IN-separate

Figure A.11 Connection to a 3-Wire Current Transformer and Cable Type Current Transformer for Sensitive Ground Fault Detection

NOTE

The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N,sep}$)!

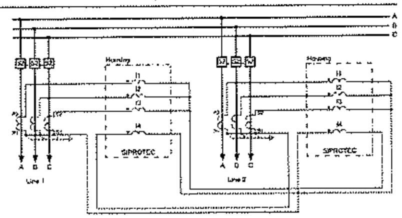


Current transformer 3-phase, connection + 3-phase + IN-separate

Figure A.12 Connection to a 3-Wire Current Transformer and Measured Ground Current from a Cable with Holmgreen Connection

NOTE

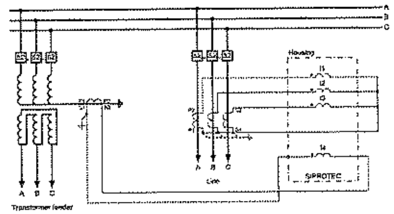
The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N,sep}$)!



Current transformer 3-phase, connection + 3-phase

Current transformer 1-phase connection + IN

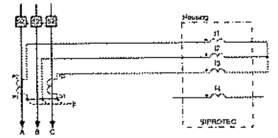
Figure A.13 Connection to a 3-Wire Current Transformer and Measured Residual Current from the Current-Transformer Neutral Point of the Respective Parallel Line (for Parallel-Line Compensation)



Current transformer 3-phase, connection + 3-phase

Current transformer 1-phase, connection + IN

Figure A.14 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.15 Connection to a 2-Wire Current Transformer - for Isolated or Resonant-Grounded Systems Only

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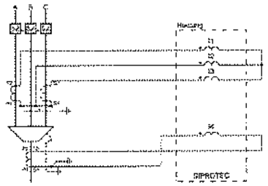
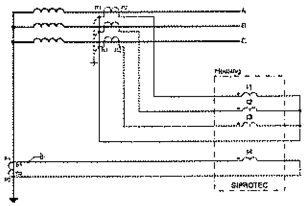


Current transformer 3-phase, connection = 3ph,2prim.CT + IN-sep

Figure A-16 Connection to a 2-Wire Current Transformer and Cable Type Current Transformer for Sensitive Ground-Fault Detection - for Isolated or Resonant-Grounded Systems Only

NOTE

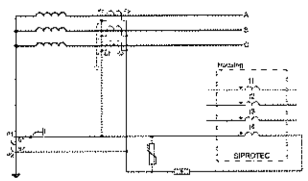
The switchover of current polarity at the 3-phase current transformer causes a rotation in the direction of electric current for current input I4 ($I_{N,sep}$)!



Current transformer 3-phase: connection = 3-phase

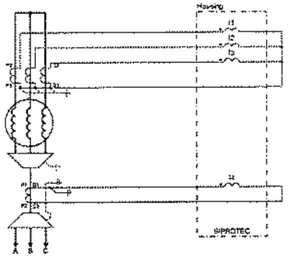
Current transformer 1-phase: connection = IX

Figure A-17 Connection to a 3-Wire Current Transformer and an Additional Current Transformer at the Neutral Point of a Grounded Power Transformer



Current transformer 1-phase: connection = IX

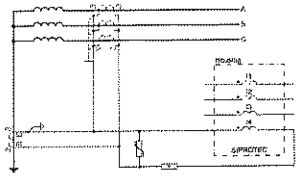
Figure A-18 Current Transformer Connection for High Impedance Differential Protection (for Example, a Power Transformer, in Preparation)



Current transformer 3-phase: connection = 3-phase

Current transformer 1-phase: connection = IX

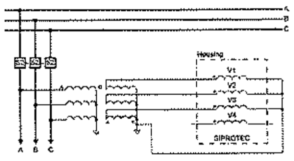
Figure A-19 Connection to a 3-Wire Current Transformer in the Neutral Point of a Generator and Cable Type Current Transformer for Sensitive Ground-Fault Detection of the Line



Current transformer 1-phase: connection = IX

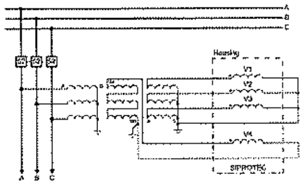
Figure A-20 Current Transformer Connection for High-Impedance Differential Protection (Example, a Power Transformer)

A.11 Connection Examples for Voltage Transformers



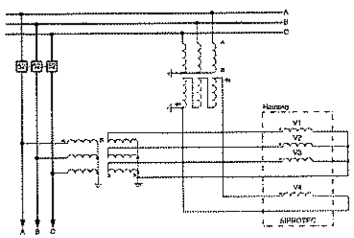
Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Figure A-21 Connection to 3 Star-Connected Voltage Transformers



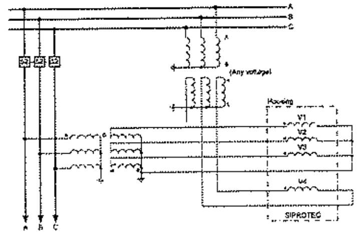
Voltage transformer 3-phase: connection = 3 ph-to-gnd volt. + VN

Figure A-22 Connection to 3 Star-Connected Voltage Transformers and to the Broken Delta Winding



Voltage transformer 3-phase: connection = 3 ph-to-gnd volt. + VN

Figure A-23 Connection to 3 Star-Connected Voltage Transformers and to the Broken Delta Winding of a Separate Voltage Transformer (for example, Busbar)



Voltage transformer 3-phase: connection = 3 ph-to-gnd voltages

Voltage transformer 1-phase: connection = VAB

Figure A-24 Connection to 3 Star-Connected Voltage Transformers and to the Phase-to-Phase Voltage of a Busbar Voltage Transformer (for Example, for Synchrocheck Applications)

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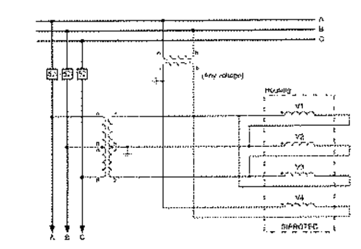
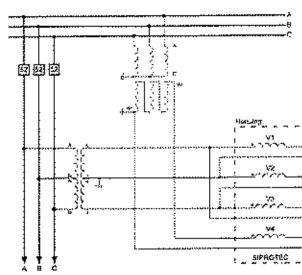


Voltage transformer 3-phase, connection = 3 ph-to-ph voltages
Voltage transformer 1-phase, connection = VAB

Figure A-25 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Phase-to-Phase Voltage of a Busbar Voltage Transformer

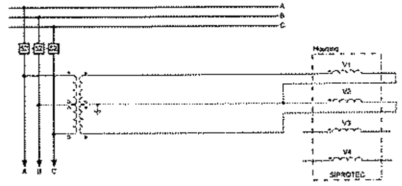
NOTE

When using the connection type 3-phase-to-phase voltage, the zero-sequence voltage cannot be detected.



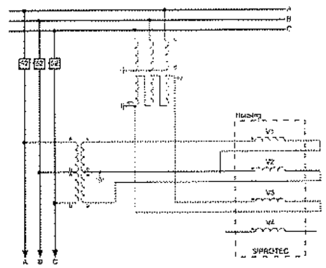
Voltage transformer 3-phase, connection = 3 ph-to-ph volt. + VN

Figure A-26 Connection to V-Connected Voltage Transformer (Delta-Connected Device Input Transformer) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



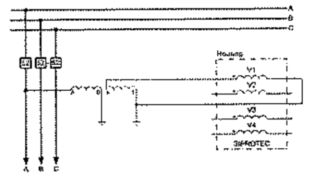
Voltage transformer 3-phase, connection = 2 ph-to-ph voltages
Phase voltages = VAB, VBC

Figure A-27 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages)



Voltage transformer 3-phase, connection = 2 ph-to-ph volt. + VN
Phase voltages = VAB, VBC

Figure A-28 Connection to V-Connected Voltage Transformer (Measurement of 2 Phase-to-Phase Voltages) and Connection to the Broken-Delta Winding of a Busbar Voltage Transformer



Voltage transformer 1-phase, connection = VA

Figure A-29 Connection to a 1-Pole Isolated Voltage Transformer (Phase-to-Ground Voltage)

A.12 Selected Connection Examples for Transformers

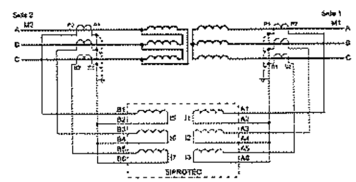


Figure A-30 Connection Example 3-Phase Transformer Without Grounded Neutral Point

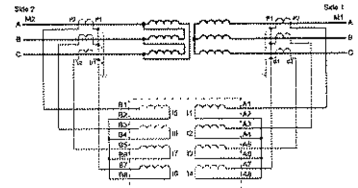


Figure A-31 Connection Example 3-phase Transformer Without Grounded Neutral Point (Additional Measured Value Acquisition on Sampling Level through Connection of 4 Current Inputs)

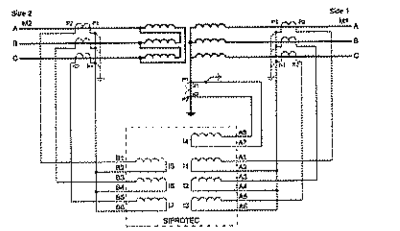


Figure A-32 Connection Example 3-Phase Transformer with Grounded Neutral Point and Current Transformer in the Neutral Point Feeder

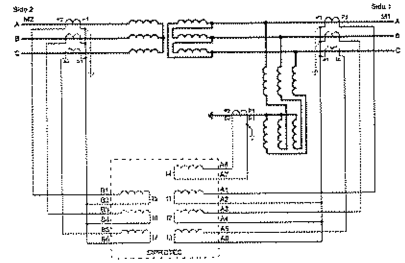
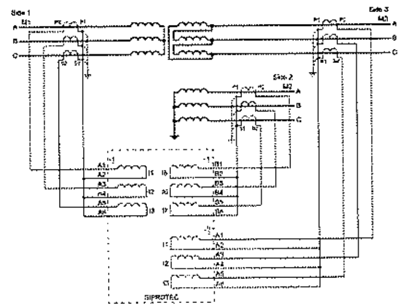


Figure A-33 Connection Example 3-Phase Transformer with Grounded Neutral Point Former and Current Transformer in the Neutral Point Feeder



*1 Base module
*2 Expansion module

Figure A-34 Connection Example 3-Phase Transformer (7UT86, 7UT87)

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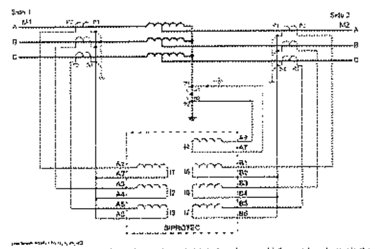
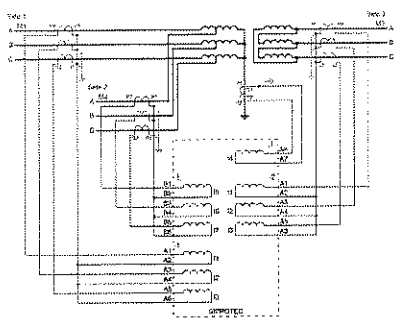
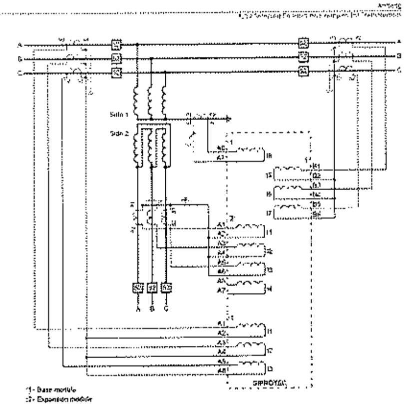


Figure A-35 Connection Example for a Grounded Auto Transformer with Current Transformer in the Neutral Point Feeder



1) Base module
2) Expansion module

Figure A-36 Connection Example for a Grounded Auto Transformer with Stabilizing Winding (tertiary winding) and Current Transformer the Neutral Point Feeder



1) Base module
2) Expansion module

Figure A-37 Connection Example for a 3-Phase Transformer with Grounded Neutral Point and Current Transformer in the Neutral Point Feeder in a 1.5 CB Design

A.13 Prerouting Two-Winding Transf. Basic, Two-Winding Transf.

Meaning of the abbreviations in DIGSI 5, see Table 2-9

Binary Inputs

Table A-2 Default Binary Inputs for Two-Winding Transf. Basic, Two-Winding Transf.

Binary Input	Signal	Number	Signal Type	Configuration	Remarks
BI1	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1:Circuit break.:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker>Ready	202.4261.500	SPS	H	

Binary Outputs

Table A-3 Default Binary Outputs for Two-Winding Transf. Basic, Two-Winding Transf.

Binary Output	Signal	Number	Signal Type	Configuration	Remarks
BO1	Circuit breaker 1:Circuit break.:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	U	

Function Keys

Table A-4 Default Function Keys for Two-Winding Transf. Basic, Two-Winding Transf.

Binary Input	Signal	Number	Signal Type	Configuration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Transformer side 1: Fund.Sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Transformer side 2: Fund.Sym.comp.			X	

Light-Emitting Diodes

Table A-5 Default LED Displays for Two-Winding Transf. Basic, Two-Winding Transf.

LEDs	Signal	Number	Signal Type	Configuration	Remarks
LED1	Transformer side 1: Group indication: Pickup: phase A Transformer side 2: Group indication: Pickup: phase A Transformer 1:Group indication: Pickup: phase A	911.4501.55 912.4501.55 901.4501.55	SPS SPS SPS	L L L	
LED2	Transformer side 1: Group indication: Pickup: phase B Transformer side 2: Group indication: Pickup: phase B Transformer 1:Group indication: Pickup: phase B	911.4501.55 912.4501.55 901.4501.55	SPS SPS SPS	L L L	
LED3	Transformer side 1: Group indication: Pickup: phase C Transformer side 2: Group indication: Pickup: phase C Transformer 1:Group indication: Pickup: phase C	911.4501.55 912.4501.55 901.4501.55	SPS SPS SPS	L L L	
LED4	Transformer side 1: Group indication: Pickup: gnd Transformer side 2: Group indication: Pickup: gnd	911.4501.55 912.4501.55	SPS SPS	L L	
LED5	Transformer side 1: Group indication: Operate: general Transformer side 2: Group indication: Operate: general Transformer 1:Group indication: Operate: general	911.4501.57 912.4501.57 901.4501.57	SPS SPS SPS	L L L	
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	U	
LED15	Alarm handling: Group warning	5971.301	SPS	H	
LED16	Device: Process mode inactive		SPS	U	

A.14 Prerouting Two-Winding Transf. 1.5 CB

Meaning of the abbreviations in DIGSI 5, see Table 2-9.

Binary Inputs

Table A-6 Default Binary Inputs for Two-Winding Transf. 1.5 CB

Binary Input	Signal	Number	Signal Type	Configuration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker>Ready	203.4261.500	SPS	H	

Binary Outputs

Table A-7 Default Output Relay for Two-Winding Transf. 1.5 CB

Binary Output	Signal	Number	Signal Type	Configuration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	U	
BO4	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	U	

Function Keys

Table A-8 Default Function Keys for Two-Winding Transf. 1.5 CB

Function Keys	Signal	Number	Signal Type	Configuration	Remarks
F-key1	General: Operational log			X	
F-key2	Main menu: Measurements Transformer side 1: Fund.Sym.comp.			X	
F-key3	General:Fault log			X	

Function Keys	Signal	Number	Signal Type	Configuration	Remarks
F-key4	Main menu: Measurements Transformer side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-9 Default LED Displays for Two-Winding Transf. 1.5 CB

LEDs	Signal	Number	Signal Type	Configuration	Remarks
LED1	Transformer side 1: Group indication: Pickup: phase A	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase A	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase A	901.4501.55	SPS	L	
LED2	Transformer side 1: Group indication: Pickup: phase B	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase B	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase B	901.4501.55	SPS	L	
LED3	Transformer side 1: Group indication: Pickup: phase C	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase C	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase C	901.4501.55	SPS	L	
LED4	Transformer side 1: Group indication: Pickup: gnd	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: gnd	912.4501.55	SPS	L	
LED5	Transformer side 1: Group indication: Operate: general	911.4501.57	SPS	L	
	Transformer side 2: Group indication: Operate: general	912.4501.57	SPS	L	
	Transformer 1:Group indication: Operate: general	901.4501.57	SPS	L	
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	U	
LED15	Alarm handling: Group warning	5971.301	SPS	U	
LED16	Device: Process mode inactive		SPS	U	

A.15 Prerouting Two-Winding Transf. Diff, Voltage Controller

Meaning of the abbreviations in DIGSI 5, see Table A-8

Binary Inputs

Table A-10 Default Binary Inputs for 2-Winding Transf. Diff, Voltage Controller

Binary Input	Signal	Number	Signal Type	Configuration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI4	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI6	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI7	Tap Changer:Position	162.13981.306	BSC	X	
BI8	Tap Changer:Position	162.13981.306	BSC	X	
BI9	Tap Changer:Position	162.13981.306	BSC	X	
BI10	Tap Changer:Position	162.13981.306	BSC	X	
BI11	Tap Changer:Position	162.13981.306	BSC	X	
BI11	Motor active		SPS	H	User defined

Binary Outputs

Table A-11 Default Output Relay for Two-Winding Transf. Diff, Voltage Controller

Binary Output	Signal	Number	Signal Type	Configuration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	U	
BO4	Transformer 1: 87T diff. prot 1: Operate: Higher cmd.	162.1391.305	ACT	X	
BO5	Transformer 1: 87T diff. prot 1: Operate: Lower cmd.	162.1391.306	ACT	X	

Function Keys

Table A-12 Default Function Keys for Two-Winding Transf. Diff, Voltage Controller

Function Keys	Signal	Number	Signal Type	Configuration	Remarks
F-key1	General:Operational log			X	

Function Keys	Signal	Number	Signal Type	Configuration	Remarks
F-key2	Main menu: Measurements Transformer side 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Transformer side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-13 Default LED Displays for Two-Winding Transf. Diff, Voltage Controller

LEDs	Signal	Number	Signal Type	Configuration	Remarks
LED1	Transformer side 1: Group indication: Pickup: phase A	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase A	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase A	901.4501.55	SPS	L	
LED2	Transformer side 1: Group indication: Pickup: phase B	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase B	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase B	901.4501.55	SPS	L	
LED3	Transformer side 1: Group indication: Pickup: phase C	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase C	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase C	901.4501.55	SPS	L	
LED4	Transformer side 1: Group indication: Pickup: gnd	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: gnd	912.4501.55	SPS	L	
LED5	Transformer side 1: Group indication: Operate: general	911.4501.57	SPS	L	
	Transformer side 2: Group indication: Operate: general	912.4501.57	SPS	L	
	Transformer 1:Group indication: Operate: general	901.4501.57	SPS	L	
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	U	
LED14	Motor active		SPS	U	User defined
LED15	Alarm handling: Group warning	5971.301	SPS	U	
LED16	Device: Process mode inactive		SPS	U	

A.16 Prerouting Motor

Meaning of the abbreviations in DIGSI 5, see Table A-8

Binary Inputs

Table A-14 Default Binary Inputs for Motor

Binary Input	Signal	Number	Signal Type	Configuration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	

Binary Outputs

Table A-15 Default Binary Outputs for Motor

Binary Output	Signal	Number	Signal Type	Configuration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	U	
BO4	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	U	

Function Keys

Table A-16 Default Function Keys for Motor

Function Keys	Signal	Number	Signal Type	Configuration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Transformer side 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Transformer side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-17 Default LED Display for Motor

LEDs	Signal	Number	Signal Type	Configuration	Remarks
LED1	Transformer side 1: Group indication: Pickup: phase A	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase A	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase A	901.4501.55	SPS	L	
LED2	Transformer side 1: Group indication: Pickup: phase B	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase B	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase B	901.4501.55	SPS	L	
LED3	Transformer side 1: Group indication: Pickup: phase C	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: phase C	912.4501.55	SPS	L	
	Transformer 1:Group indication: Pickup: phase C	901.4501.55	SPS	L	
LED4	Transformer side 1: Group indication: Pickup: gnd	911.4501.55	SPS	L	
	Transformer side 2: Group indication: Pickup: gnd	912.4501.55	SPS	L	
LED5	Transformer side 1: Group indication: Operate: general	911.4501.57	SPS	L	
	Transformer side 2: Group indication: Operate: general	912.4501.57	SPS	L	
	Transformer 1:Group indication: Operate: general	901.4501.57	SPS	L	
LED8	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	U	
LED15	Alarm handling: Group warning	5971.301	SPS	U	
LED16	Device: Process mode inactive		SPS	U	

A.17 Prerouting Three-Winding Transformers

Meaning of the abbreviations in DIGSI 5, see Table A-8.

Binary Inputs

Table A-18 Default Binary Inputs for Three-Winding Transformer

Binary Input	Signal	Number	Signal Type	Configuration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:>Ready	203.4261.500	SPS	H	

Binary Outputs

Table A-19 Default Binary Outputs for Three-Winding Transformers

Binary Output	Signal	Number	Signal Type	Configuration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	U	
BO4	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	U	

Function Keys

Table A-20 Default Function Keys for Three-Winding Transformers

Function Keys	Signal	Number	Signal Type	Configuration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Transformer side 1: Fund./sym.comp.			X	
F-key3	General:Fault log			X	

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Function Keys	Signal	Number	Signal Type	Configu-ration	Remarks
F-Key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-21 Default LED Displays for Three-Winding Transformers

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer 1:Group indication: Pickup: phase A	901.4501.55	SPS	L	
LED2	Transformer 1:Group indication: Pickup: phase B	901.4501.55	SPS	L	
LED3	Transformer 1:Group indication: Pickup: phase C	901.4501.55	SPS	L	
LED6	Transformer 1:Group indication: Operate: general	901.4501.57	SPS	L	
LED15	Alarm handling: Group warning	5971.301	SPS	U	
LED16	Device: Process mode inactive		SPS	U	

A.18 Prerouting Three-Winding Transf. 1.5 CB

Meaning of the abbreviations in DIGSI 5, see Table A-1.

Binary Inputs

Table A-22 Default Binary Inputs for Three-Winding Transf. 1.5 CB

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Posi-tion	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Posi-tion	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Posi-tion	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Posi-tion	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Posi-tion	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Posi-tion	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:Ready	203.4261.500	SPS	H	
BI11	Circuit breaker 4: Circuit Breaker:Posi-tion	204.4261.58	DPC	OH	
BI12	Circuit breaker 4: Circuit Breaker:Posi-tion	204.4261.58	DPC	CH	
BI13	Circuit breaker 4: Circuit Breaker:Ready	204.4261.500	SPS	H	

Binary Outputs

Table A-23 Default Standard Relay for Three-Winding Transf. 1.5 CB

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	U	
BO4	Circuit breaker 4: Circuit Breaker:Trip/open cmd.	204.4261.300	SPS	U	
BO5	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	U	

Function Keys

Table A-24 Default Function Keys for Three-Winding Transf. 1.5 CB

Function Keys	Signal	Number	Signal Type	Configu-ration	Remarks
F-Key1	General:Operational log			X	
F-Key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	
F-Key3	General:Fault log			X	
F-Key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	
F-Key5	Main menu: Measurements Trans-former side 3: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-25 Default LED Displays for Three-Winding Transf. 1.5 CB

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer side 1: Group indication: Pickup: phase A Transformer 1:Group indication: Pickup: phase A	911.4501.55 901.4501.55	SPS SPS	L L	
LED2	Transformer side 1: Group indication: Pickup: phase B Transformer 1:Group indication: Pickup: phase B	911.4501.55 901.4501.55	SPS SPS	L L	
LED3	Transformer side 1: Group indication: Pickup: phase C Transformer 1:Group indication: Pickup: phase C	911.4501.55 901.4501.55	SPS SPS	L L	
LED4	Transformer side 1: Group indication: Pickup, gnd Transformer sarp. 1: Group indica-tion: Pickup: general	911.4501.55 912.4501.55	SPS SPS	L L	
LED5	Transformer side 1: Group indication: Operate: general Transformer sarp. 1: Group indica-tion: Operate: general Transformer 1:Group indication: Operate: general	911.4501.57 912.4501.57 901.4501.57	SPS SPS SPS	L L L	
LED6	Transformer side 1: 49 Th.overl. 1: Thermal warning	911.601.302	SPS	U	
LED15	Alarm handling: Group warning	5971.301	SPS	U	
LED16	Device: Process mode inactive		SPS	U	

A.19 Prerouting Three-Winding Transf. DIFF, EDS, DIS

Meaning of the abbreviations in DIGSI 5, see Table A-1.

Binary Inputs

Table A-26 Default Binary Inputs for Three-Winding Transf. DIFF, EDS, DIS

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Posi-tion	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Posi-tion	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Posi-tion	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Posi-tion	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Posi-tion	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Posi-tion	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:Ready	203.4261.500	SPS	H	

Binary Outputs

Table A-27 Default Binary Outputs for Three-Winding Transf. DIFF, EDS, DIS

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	U	
BO4	Transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	U	

Function Keys

Table A-28 Default Function Keys for Three-Winding Transf. DIFF, EDS, DIS

Function Keys	Signal	Number	Signal Type	Configu-ration	Remarks
F-Key1	General:Operational log			X	
F-Key2	Main menu: Measurements Trans-former side 1: Fund./sym.comp.			X	
F-Key3	General:Fault log			X	

Function Keys	Signal	Number	Signal Type	Configu-ration	Remarks
F-Key4	Main menu: Measurements Trans-former side 2: Fund./sym.comp.			X	

Light-Emitting Diodes

Table A-29 Default LED Displays for Three-Winding Transf. DIFF, EDS, DIS

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Transformer 1:Group indication: Pickup: phase A	901.4501.55	SPS	L	
LED2	Transformer 1:Group indication: Pickup: phase B	901.4501.55	SPS	L	
LED3	Transformer 1:Group indication: Pickup: phase C	901.4501.55	SPS	L	
LED6	Transformer 1:Group indication: Operate: general	901.4501.57	SPS	L	
LED15	Alarm handling: Group warning	5971.301	SPS	U	
LED16	Device: Process mode inactive		SPS	U	

A.20 Prerouting Auto Transformer

Meaning of the abbreviations in DIGSI 5, see Table A-1.

Binary Inputs

Table A-30 Default Binary Inputs for Auto Transformer

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Posi-tion	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Posi-tion	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker:Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Posi-tion	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Posi-tion	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker:Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Posi-tion	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Posi-tion	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker:Ready	203.4261.500	SPS	H	

Binary Outputs

Table A-31 Default Binary Outputs for Auto Transformer

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	U	
BO5	Auto-transformer 1: 87T diff. prot 1: Operate: general	901.1691.4501.57	ACT	U	

Function Keys

Table A-32 Default Function Keys for Auto Transformer

Function Keys	Signal	Number	Signal Type	Configu-ration	Remarks
F-Key1	General:Operational log			X	
F-Key2	Main menu: Measurements Auto transf. side 1: Fund./sym.comp.			X	
F-Key3	General:Fault log			X	

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Function Keys	Signal	Number	Signal Type	Configu-ration	Remarks
F-key4	Main menu: Measurements Auto transf. autoside 2: Fund.sym.comp.			X	
F-key5	Main menu: Measurements Auto transf. Compside: Fund.sym.comp.			X	

Light-Emitting Diodes

Table A-33 Default LED Displays for Auto Transformer

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Auto transf. autoside 1: Group indication: Pickup: phase A Auto transf. autoside 2: Group indication: Pickup: phase A Auto transf. Comp side: Group indication: Pickup: phase A Auto transformer 1: Group indication: Pickup: phase A	941.4501.55 942.4501.55 951.4501.55 931.4501.55	SPS SPS SPS SPS	L L L L	
LED2	Auto transf. autoside 1: Group indication: Pickup: phase B Auto transf. autoside 2: Group indication: Pickup: phase B Auto transf. Comp.side: Group indication: Pickup: phase B Auto Transformer 1: Group indication: Pickup: phase B	941.4501.55 942.4501.55 951.4501.55 931.4501.55	SPS SPS SPS SPS	L L L L	
LED3	Auto transf. autoside 1: Group indication: Pickup: phase C Auto transf. autoside 2: Group indication: Pickup: phase C Auto transf. Comp.side: Group indication: Pickup: phase C Auto Transformer 1: Group indication: Pickup: phase C	941.4501.55 942.4501.55 951.4501.55 931.4501.55	SPS SPS SPS SPS	L L L L	
LED4	Auto transf. autoside 1: Group indication: Pickup: gnd Auto transf. autoside 2: Group indication: Pickup: gnd Auto transf. Comp side: Group indication: Pickup: gnd Auto transf. Neutral point 1: Group indication: Pickup: general	941.4501.55 942.4501.55 951.4501.55 971.4501.57	SPS SPS SPS SPS	L L L L	

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED5	Auto transf. autoside 1: Group indication: Operate: general Auto transf. autoside 2: Group indication: Operate: general Auto transf. Comp side: Group indication: Pickup: gnd Auto Transformer 1: Group indication: Operate: general Auto transf. Neutral point 1: Group indication: Operate: general	941.4501.57 942.4501.57 951.4501.57 931.4501.57 971.4501.57	SPS SPS SPS SPS SPS	L L L L L	
LED6	Auto transf. autoside 1: 49 Th.overl. 1: Thermal warning	941.601.302	SPS	U	
LED15	Alarm handling: Group warning	5971.301	SPS	U	
LED16	Device: Process mode inactive		SPS	U	

A.21 Prerouting Auto Transformer 1.5 CB

Meaning of the abbreviations in DIGSI 5, see Table A-1

Binary Inputs

Table A-34 Default Binary Inputs for Auto Transformer 1.5 CB

Binary Input	Signal	Number	Signal Type	Configu-ration	Remarks
BI1	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	OH	
BI2	Circuit breaker 1: Circuit Breaker:Position	201.4261.58	DPC	CH	
BI3	Circuit breaker 1: Circuit Breaker>Ready	201.4261.500	SPS	H	
BI5	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	OH	
BI6	Circuit breaker 2: Circuit Breaker:Position	202.4261.58	DPC	CH	
BI7	Circuit breaker 2: Circuit Breaker>Ready	202.4261.500	SPS	H	
BI8	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	OH	
BI9	Circuit breaker 3: Circuit Breaker:Position	203.4261.58	DPC	CH	
BI10	Circuit breaker 3: Circuit Breaker>Ready	203.4261.500	SPS	H	
BI11	Circuit breaker 4: Circuit Breaker:Position	204.4261.58	DPC	OH	
BI12	Circuit breaker 4: Circuit Breaker:Position	204.4261.58	DPC	CH	
BI13	Circuit breaker 4: Circuit Breaker>Ready	204.4261.500	SPS	H	

Binary Outputs

Table A-35 Default Binary Outputs for Auto Transformer 1.5 CB

Binary Output	Signal	Number	Signal Type	Configu-ration	Remarks
BO1	Circuit breaker 1: Circuit Breaker:Trip/open cmd.	201.4261.300	SPS	U	
BO2	Circuit breaker 2: Circuit Breaker:Trip/open cmd.	202.4261.300	SPS	U	
BO3	Circuit breaker 3: Circuit Breaker:Trip/open cmd.	203.4261.300	SPS	U	
BO4	Circuit breaker 4: Circuit Breaker:Trip/open cmd.	204.4261.300	SPS	U	
BO5	Auto transformer 1: 87T diff. prot 1: Operate: general Auto transformer 1: 87T diff. prot 2 Operate: general	931.1691.4501.57 931.1692.4501.57	ACT ACT	U U	

Function Keys

Table A-36 Default Function Keys for Auto Transformer 1.5 CB

Function Keys	Signal	Number	Signal Type	Configu-ration	Remarks
F-key1	General:Operational log			X	
F-key2	Main menu: Measurements Auto transf. autoside 1: Fund.sym.comp.			X	
F-key3	General:Fault log			X	
F-key4	Main menu: Measurements Auto transf. autoside 2: Fund.sym.comp.			X	
F-key5	Main menu: Measurements Auto transf. Compside: Fund.sym.comp.			X	

Light-Emitting Diodes

Table A-37 Default LED Displays for Auto Transformer 1.5 CB

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED1	Auto transf. autoside 1: Group indication: Pickup: phase A Auto transf. autoside 2: Group indication: Pickup: phase A Auto transf. Comp side: Group indication: Pickup: phase A Auto transformer 1: Group indication: Pickup: phase A	941.4501.55 942.4501.55 951.4501.55 931.4501.55	SPS SPS SPS SPS	L L L L	
LED2	Auto transf. autoside 1: Group indication: Pickup: phase B Auto transf. autoside 2: Group indication: Pickup: phase B Auto transf. Comp.side: Group indication: Pickup: phase B Auto Transformer 1: Group indication: Pickup: phase B	941.4501.55 942.4501.55 951.4501.55 931.4501.55	SPS SPS SPS SPS	L L L L	
LED3	Auto transf. autoside 1: Group indication: Pickup: phase C Auto transf. autoside 2: Group indication: Pickup: phase C Auto transf. Comp.side: Group indication: Pickup: phase C Auto Transformer 1: Group indication: Pickup: phase C	941.4501.55 942.4501.55 951.4501.55 931.4501.55	SPS SPS SPS SPS	L L L L	
LED4	Auto transf. autoside 1: Group indication: Pickup: gnd Auto transf. autoside 2: Group indication: Pickup: gnd Auto transf. Comp side: Group indication: Pickup: gnd	941.4501.55 942.4501.55 951.4501.55	SPS SPS SPS	L L L	

LEDs	Signal	Number	Signal Type	Configu-ration	Remarks
LED5	Auto transf. autoside 1: Group indication: Operate: general Auto transf. autoside 2: Group indication: Operate: general Auto transf. Comp.side: Group indication: Operate: general Auto Transformer 1: Group indication: Operate: general	941.4501.57 942.4501.57 951.4501.57 931.4501.57	SPS SPS SPS SPS	L L L L	
LED8	Auto transf. autoside 1: 49 Th.overl. 1: Thermal warning	941.601.302	SPS	U	
LED15	Alarm handling: Group warning	5971.301	SPS	U	
LED16	Device: Process mode inactive		SPS	U	

Glossary

ACD

IEC 61850 data type: Directional protection activation information

ACK

Data transfer acknowledgment

ACT

IEC 61850 data type: Protection activation information

APC

Controllable analog set point information

ASDU

ASDU stands for Application Service Data Unit. An ASDU can consist of one or more identical information objects. A sequence of the same information elements, for example measured values, is identified by the address of the information object. The address of the information object defines the associated address of the first information element of the sequence. A consecutive number identifies the subsequent information elements. The number builds on this address in integral increments (+1).

BAC

Binary Controlled Analog Process Value

Back-up battery

The back-up battery ensures that specified data areas, flags, timers and counters are kept retentive.

Bay Controller

Bay controllers are devices with control and monitoring functions without protection functions.

BCR

IEC 61850 data type: Binary counter reading

Best master clock algorithm

A PTP network contains communicating clocks. With the best master clock algorithm (BMC), the device indicating the most precise time is determined. This device is used as a reference clock and is designated as grandmaster. If the network topology is changed, the BMC algorithm is executed again on network segments that are possibly disconnected from the grandmaster. If a participating device is a master and a slave, it is called a boundary clock.

Big endian

Big-endian and little-endian describe the order in which a sequence of bytes is stored. In big-endian systems the most significant byte is stored at the lowest storage address. In little-endian systems, the most significant byte is stored at the highest storage address.

Binary Controlled Analog Process Value

The data type BAC represents a command with or without feedback. The BAC is used for example for the control of an arc suppression coil. The commands Higher, Lower, and Step are possible. The feedback from the process is an analog value.

Binary Controlled Step Position

The data type BSC can, for example, be used to control a transformer tap changer. The commands up, down can be given.

Bit pattern indication

A bit pattern indication is a processing function, with the help of which adjacent numerical process information can be logged coherently and processed further in parallel via multiple inputs. The bit pattern indication can be selected as 1, 2, 3 or 4 bytes.

BMC

See best master clock algorithm

Boundary Clock

The Precision Time Protocol knows different types of clocks: an ordinary clock (abbreviation: OC), a boundary clock (BC), and a transparent clock (TC). The boundary clock transports time information over a network limit, for example, in a router connecting different switched networks. As a slave, the clock of the router receives the time information and transmits this further on as a master.

BRCB

Buffered Report Control Block

BSC

Binary Controlled Step Position

Buffered Report Control Block

Buffered Report Control Block (BRCB) is a form of report controlling. Internal events trigger the immediate sending of reports or saving of events for the transfer. Data values cannot therefore be lost on account of transport flow control conditions or connection interruptions. BRCB provides the functionality SOE (See Sequence of Events).

CB

Circuit breaker

CDC

Common Data Class

CFC

Continuous Function Chart

Chatter Blocking

A rapidly intermittent input (for example, owing to a relay contact fault) is disconnected after a parameterizable monitoring time and therefore cannot generate any more signal changes. The function prevents the system from overloading in the event of an error.

CID

Configured IED Description

CMV

Complex measured value

Combination Device

Combination devices are bay units with protection functions and with feeder mimic diagram.

Common Data Class

Generic term for a data class according to the IEC 61850 model.

Communication branch

A communication branch corresponds to the configuration of 1 to n participants communicating via a joint bus.

Configured IED Description

A Configured IED Description (CID) is a file for data exchange between the IED Configuration Tool and the IED itself.

Container

If an object contains other objects, this is referred to as a container. The object Folder for example is such a container.

Continuous Function Chart

The Continuous Function Chart (CFC) is a programming language. It is used for programmable logic controllers. The programming language Continuous Function Chart is not defined in the standard IEC 61131-3, but represents a current extension of IEC programming environments. CFC is a graphic programming language. Function blocks are linked to one another. This represents an essential difference from conventional programming languages, where sequences of commands are entered.

Control display

The control display becomes visible for devices with a large display after pressing the Control key. The diagram contains the switching devices to be controlled in the feeder. The control display serves for implementing switching operations. Specification of this diagram forms part of configuring.

Controllable Integer Status

The data type INC can be used to issue a command (to one or more relays, selectable under information routing) that is monitored via a whole number as feedback.

Controller

The controller initiates the IO data communication.

CRC

Cyclic redundancy check

Data type

The data type is a value set of a data object, together with the operations allowed on this value set. A data type contains a classification of a data element, such as the determination whether it consists of integers, letters, or similar.

Data unit

Information item with a joint transmission source. Abbreviation: DU = Data Unit

Data window

The right area of the project window visualizes the 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.

DCF

Device Configuration File. Device parameterization

DCF77

The precise official time is determined in Germany by the Physikalisch-Technische Bundesanstalt PTB in Braunschweig. The atomic clock unit of the PTB transmits this time via the long-wave time signal transmitter in Mainflingen near Frankfurt/Main. The emitted time signal can be received within a radius of approx. 1500 km from Frankfurt/Main.

DCP

Discovery and Basic Configuration Protocol

DDD

SIPROTEC 5 device driver (DIGSI 5 Device Driver)

DEL

Phase-to-phase related measurements of a 3-phase system

Device 5 Export Format

DEX5

Device Container

In the component view, all SIPROTEC devices are subordinate to an object of the device container type. This object is also a special object from the DIGSI Manager. However, as there is no component view in the DIGSI 5 Manager, this object only becomes visible in conjunction with STEP 7.

DEX5

Device 5 Export Format
You can archive the data from an individual SIPROTEC 5 device in DEX5 format.

DHCP

Dynamic Host Configuration Protocol

DIGDNP

DIGSI 5 protocol settings for DNP3
File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGMOD

DIGSI 5 protocol settings for Modbus TCP
File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGSI 5 Display Pages

You can archive individual or all display pages of a SIPROTEC 5 device in DSPS format. You can also use this format to exchange display pages between SIPROTEC 5 devices. The DSPS format is based on XML.

DIGSI 5 protocol settings for DNP3

If the DNP3 protocol is configured for a system interface, you can export the protocol settings in DIGDNP format. The DIGDNP format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for IEC 60870-5-103

If the IEC 60870-5-103 protocol is configured for a system interface, you can export the protocol settings in DIGT103 format. The DIGT103 format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for IEC 60870-5-104

If the IEC 60870-5-104 protocol is configured for a system interface, you can export the protocol settings in DIGT104 format. The DIGT104 format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 protocol settings for Modbus TCP

If the Modbus TCP protocol is configured for a system interface, you can export the protocol settings in DIGMOD format. The DIGMOD format is specially designed to transmit interface data from DIGSI 5 into the SICAM PAS substation automation system.

DIGSI 5 Test Sequences

You can archive individual or all test sequences of a SIPROTEC 5 device in SEQS format. You can also use this format to exchange test sequences between SIPROTEC 5 devices. The SEQS format is based on XML.

DIGSI

Configuration software for SIPROTEC

DIGT103

DIGSI 5 protocol settings for IEC 60870-5-103
File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

DIGT104

DIGSI 5 protocol settings for IEC 60870-5-104
File extension for a file generated by DIGSI for exporting the protocol configuration from DIGSI 5.

Discovery and Basic Configuration Protocol

The DCP protocol is used to detect devices without IP addresses and to assign addresses to these devices.

DNP3

DNP3 is a communications standard for telecontrol engineering. DNP3 is used as a general transmission protocol between control systems and substations and between bay devices and the systems control.

Double Command

Double commands (DPC – Double Point Control) are process outputs which visualize 4 process states at 2 outputs: 2 defined states (for example, On/Off) and 2 undefined states (for example, disturbed positions).

Double-point indication

Double-point indications (DPS – Double point status) are process indications which visualize 4 process states at 2 inputs: 2 defined states (for example, On/Off and disturbed position) and 1 undefined state (00).

DPC

IEC 61850 data type: Double Point Control

DPS

IEC 61850 data type: Double-point status

Drag and drop

Copying, moving, and linking function, used in graphic user interfaces. The mouse is used to highlight and hold objects and then move them from one data area to another.

DSPS

DIGSI 5 Display Pages

DU

Data unit

Dynamic Host Configuration Protocol

In order to configure PCs automatically, centralized and uniformly in a TCP/IP network, a dynamic assignment of IP addresses is used. DHCP is used. The system administrator determines how the IP addresses are to be assigned and specifies the time lapse over which they are assigned. DHCP is defined in the Internet standards RFC 2131 (03/97) and RFC 2241 (11/97).
For SIPROTEC 5, a device can also be assigned an IP address via DIGSI via DHCP.

ELCAD

Electrical CAD

Electrical CAD

You can import the topology information contained in an ELCAD file into a project and use it as the basis for a single-line configuration. The other information contained in the ELCAD file is not included in this process.

Electromagnetic Compatibility

Electromagnetic compatibility (EMC) means that an item of electrical equipment functions without error in a specified environment. The environment is not influenced in any impermissible way here.

ENC

Enumerated Status Controllable

ENS

Enumerated Status

ESD Protection

ESD protection is the totality 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 use a fiber-optic interface. If a receive line interruption is detected, the link status at the fiber is changed. The status change leads to deletion of the LED 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 interface then immediately blocks the transmit line and signals the connection failure to the other device. The FEFI setting in the switch triggers detection of the error on the receive line of the switch.

FEFI

Far End Fault Indication

FG

Function group

Fleeting indications

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 (first-coming).

Floating

Floating means that a free potential not connected to ground is generated. Therefore no current flows through the body to ground in the event of touching.

Folder

This object type helps when structuring a project hierarchically.

Function group

Functions are brought together into function groups (FG). The assignment of functions to current and/or voltage transformers (assignment of functions to measuring points), the information exchange between the function groups via interfaces as well as the generation of group indications are important for this bringing together.

General Interrogation

The state of all process inputs, of the status, and of the error image are scanned on system startup. This information is used to update the system-side process image. Likewise, the current process state can be interrogated after data loss with a general interrogation (GA).

General Station Description Mark-up Language

GSDML is an XML-based description language for creating a GSD file.

Generic Object-Oriented Substation Event

GOOSE, Protocol of IEC 61850 for communication between bay units.

GI

General Interrogation

GIN

Generic Identification Number

GOOSE

Generic Object-Oriented Substation Event

Ground

The conductive ground whose electric potential can be set equal to 0 at every point. In the area of grounding electrodes, the ground can have a potential deviating from 0. The term reference ground is also used for this situation.

Grounding

The grounding is the entirety of all means and measures for grounding.

GSDML

General Station Description Mark-up Language

Hierarchy Level

In a structure with superordinate and subordinate objects, a hierarchy level is a level of equal-ranking objects.

High Availability Seamless Redundancy Protocol

The PRP (Parallel Redundancy Protocol), HSR (High Availability Seamless Redundancy Protocol) is specified in IEC 62439-3. Both protocols offer redundancy without switching time.

The principal function can be found in the definition of PRP. With PRP, the same indication is sent via 2 separated networks. In contrast to this, in the case of HSR the indication is sent twice in the 2 directions of the ring. The recipient receives it correspondingly via 2 paths in the ring, takes the 1st message and discards the 2nd (see PRP).

Whereas NO indications are forwarded in the end device in the case of PRP, a switch function is installed in the HSR node. Thus, the HSR node forwards indication in the ring that are not directed at it.

In order to avoid circular messages in the ring, corresponding mechanisms are defined in the case of HSR.

SAN (Single Attached Node) end devices can only be connected with the aid of a REDBOX. In the case of HSR, PRP systems and HSR systems can be coupled redundantly with 2 REDBOXES.

HMI

Human Machine Interface

HSR

High Availability Seamless Redundancy Protocol

HV bay description

The HV project description file contains data concerning which bays are present within a ModPara project. The actual bay information is saved for each bay in an HV bay description file. Within the HV project description file, each bay receives an HV bay description file through a reference to the file name.

HV Project Description

If the configuring and parameterization of PCUs and submodules is completed with ModPara, all the data will be exported. The data is distributed to several files during this process. A file contains data on the basic project structure. This typically includes information on which bays are present within this project. This file is designated as an HV project description file.

ICD

IED Capability Description

IEC

International Electrotechnical Commission

IEC 60870-5-103

International standard protocol for communication with IEDs (especially protective equipment). Many protective relays, bay devices, bay controllers and measurement acquisition devices use the IEC 60870-5-103 protocol to communicate with the SICAM system.

IEC 60870-5-104

Internationally standardized telecontrol protocol. Transmission protocol based on IEC 60870-5-101 for the connection of the substation control level to the telecontrol center using TCP/IP via a Wide Area Network (WAN) connection.

IEC 60870-5-104 is also used for the communication with IEDs.

IEC 61850

IEC 61850 is an international standard for consistent communication in substations. This standard defines the communication amongst devices in substations and the related system requirements. All substation automation functions as well as engineering functions are supported. IEC 61850 can also be transferred to automation systems in other applications, for example, for the control and monitoring of distributed power generation.

IEC address

A unique IEC address must be assigned to each SIPROTEC device within an IEC bus. A total of 254 IEC addresses per IEC bus are available.

IEC communication branch

Within an IEC communication branch, the participants communicate on the basis of the protocol IEC 60870-5-103 via an IEC bus.

IED Capability Description

Data exchange from the IED configuration software (DIGSI) to the system configurator. This file describes the performance properties of an IED.

IEEE 1588

Time synchronization protocol according to IEEE Std 1588-2008: Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (IEEE 1588 v2) and IEEE Std C37.238-2011: IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications (Power Profile)

IID

Instantiated IED Description

INC

Controllable Integer Status

Initialization string

An initialization string consists of a series of modem-specific commands. If the modem is initialized, these commands are transferred to the modem. The commands can force defined settings for the modem, for example.

Input Data/Input Direction

Data is sent from the protocol slave to the protocol master.

INS

Integer Status

Instantiated IED Description

Files in IID format are ICD files adapted for the concrete application in the project. This format is mainly suitable for exchanging data between DIGSI 5 and an external system configurator in also a substation automation system such as SICAM PAS. The ICD format uses SCL as the description language for this purpose.

International Electrotechnical Commission

IEC

Internet protocol

An Internet protocol (IP) enables the connection of participants which are positioned in different networks.

IO

Input-Output

IO Provider Status

The provider (sender) of an IO data element uses this to signal the status (good/bad with error location).

IOPS

IO Provider Status

IP

Internet protocol

IPv4

Internet protocol version 4

ISC

Integer Step Controlled Position Information

LAN

Local Area Network

Link Address

The link address indicates the address of a SIPROTEC device.

Link Layer Discovery Protocol

The Link Layer Discovery Protocol supplies the basis for topology detection and for determination of the configuration.

List view

The right area of the project window displays the names and symbols of the objects which are within a container selected in the overview. As the visualization is in the form of a list, this area is also referred to as list view.

LLDP

Link Layer Discovery Protocol

Local Area Network

A Local Area Network (LAN) is a regional, local PC network. The PCs are all equipped with a network interface card and work with one another via data exchange. The LAN requires an operating system on each PC and standardized data transport software. The operating systems can be different, as can the data transport software, but both must support a common transmission protocol (→ TCP/IP protocols), so that all PCs can exchange data with one another.

LSB

Least Significant Bit

MAC address

The MAC address (Media Access Control) is the hardware address of each single system adapter. With the MAC address, the device can be identified unambiguously in the system.

Management Information Base

A Management Information Base (MIB) is a database which saves information and statistics concerning each device in a network continuously. The performance of each device can be monitored with this information and statistics. In this way, it can also be ensured that all devices in the network function properly. MIBs are used with SNMP.

Manufacturing Message Specification

The standard Manufacturing Message Specification (MMS) serves for data exchange. The standard is used for the transmission protocols IEC 61850 and IEC 60870-6 TASE.2.

Measured Value

This data type provides a measured value that can be used as a CFC result, for instance.

Metered value

Metered values are a processing function, used to determine the total number of discrete similar events (counting pulses), for example, as integral over a time span. In the power supply utility field, electrical energy is often recorded as a metered value (energy import/delivery, energy transport).

MIB

Management Information Base

MICS

Model Implementation Conformance Statement

MMS

Manufacturing Message Specification

Modbus

The Modbus protocol is a communication protocol. It is based on a Master/Slave or Client/Server architecture.

Model Implementation Conformance Statement

Model Implementation Conformance Statement (see MICS)

The Model Implementation Conformance Statement describes in detail the standard data object models that are supported by the system or by the device.

Modem

Modem profiles for a modem connection are saved in this object type.

Modem Connection

This object type contains information on the two partners of a modem connection, local modem and remote modem.

Modem Profile

A modem profile comprises the name of the profile, a modem driver and optionally several initialization commands as well as a participant address. You can create multiple modem profiles for a physical modem. For this, link different initialization commands or participant addresses with a modem driver and its properties, and save these under various names.

Module

Self-contained unit at the device level. This can be a real module or a functional unit of the device.

MSB

Most Significant Bit

MV

Data type Measured Value

NACK

Negative acknowledgment

Navigation Window

Left area of the project window, which visualizes the names and symbols of all containers of a project in the form of a hierarchical tree structure.

Object

Each element of a project structure is designated as an object in DIGSI 5.

Object Property

Each object has properties. These can on the one hand be general properties that are common to several objects. Otherwise, an object can also have object-specific properties.

Offline

If there is no communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is offline. The PC program executes in Offline mode.

Online

If there is a communication connection between a PC program (for example, configuration program) and a runtime application (for example, a PC application), the PC program is online. The PC program executes in Online mode.

Optical Switch Module

An Optical Switch Module (OSM) is a process for switching over switches in Ethernet networks that are ring-shaped in structure. OSM is a proprietary process from Siemens, which later became standard under the term MRP. OSM is integrated in the optical Ethernet module EN100 O. OSM is hardly used in IEC 61850 networks. RSTP is used there, this having become established as an international standard.

OSM

Optical Switch Module

889

Output data/Output direction

Data is sent from the protocol master to the protocol slave.

Parallel Redundancy Protocol

Parallel Redundancy Protocol (PRP) is a redundancy protocol for Ethernet networks that is specified in IEC 62439-3. Unlike conventional redundancy procedures, such as RSTP (Rapid Spanning Tree Protocol, IEEE 802.1D-2004), PRP offers uninterruptible switching, which avoids any down time in the event of a fault, and thus the highest availability.

PRP is based on the following approach: The redundancy procedure is generated in the end device itself. The principle is simple: The redundant end device has 2 Ethernet interfaces with the same address (DAN, Double Attached Node). Now, the same indication is sent twice, in the case of PRP (parallel) to 2 separate networks, and uniquely marks both with a sequence number. The recipient takes the information that is received first, stores its ID based on the source address and the sequence number in a duplicate filter and thus recognizes the 2nd, redundant information. This redundant information is then discarded. If the 1st indication is missing, the 2nd indication with the same content comes via the other network. This redundancy avoids a switching procedure in the network and is thus interruption-free. The end device forwards no messages to the other network. Since the process is realized in the Ethernet layer (same MAC address), it is transparent and usable for all Ethernet payload protocols (IEC 61850, DNP, other TCP/IP based protocols). In addition, it is possible to use one of the 2 networks for the transmission of non-redundant messages.

There are 2 versions of PRP: PRP-0 and its successor PRP-1. Siemens implements PRP-1.

Parameterization

Comprehensive term for all setting work on the device. You can parameterize the protection functions with DIGSI 5 or sometimes also directly on the device.

Parameter set

The parameter set is the entirety of all parameters that can be set for a SIPROTEC device.

Participant address

A participant address consists of the name of the participant, the international dialing code, the local dialing code and the participant-specific telephone number.

PICS

Protocol Implementation Conformance Statement

PLC

See Programmable Logic Controller

PLC

Programmable Logic Controller

PROFIBUS

PROcess Field BUS, German Process and Fieldbus standard (EN 50170). The standard specifies the functional, electrical and mechanical characteristics for a bit-serial fieldbus.

PROFIBUS Address

A unique PROFIBUS address must be assigned to each SIPROTEC device within a PROFIBUS network. A total of 254 PROFIBUS addresses per PROFIBUS network are available.

Profile_ID

A Profile_ID in combination with an API uniquely identifies the access and the behavior of an application

PROFINET IO

PROFINET IO is an open Industrial Ethernet Standard from PROFIBUS for the automation.

Programmable Logic

The programmable logic is a function in Siemens devices or station controllers, enabling user-specific functionality in the form of a program. This logic component can be programmed by various methods: CFC (Continuous Function Chart) is one of these. SFC (Sequential Function Chart) and ST (Structured Text) are others.

Programmable Logic Controller

Programmable-logic controllers (PLC) are electronic controllers whose function is saved as a program in the control unit. The construction and wiring of the device do not therefore depend on the function of the control. The programmable logic controller has the structure of a computer; it consists of CPU with memory, input/output modules in 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.

Project tree

The Project tree is used to display a data structure. This data structure represents the content of the project and is created by a Generic Browser.

Protection communication

Protection communication includes all functionalities necessary for data exchange via the protection interface. Protection communication is created automatically during configuration of communication channels.

Protection Device

A protection device detects erroneous states in distribution networks, taking into account various criteria, such as error distance, error direction or fault direction, triggering a disconnection of the defective network section.

Protocol Implementation Conformance Statement

The performance properties of the systems to be tested are summarized in the report on the conformity of implementation of a protocol (PICS = Protocol Implementation Conformance Statement).

PRP

Parallel Redundancy Protocol

Rapid Spanning Tree Protocol

The Rapid Spanning Tree Protocol (RSTP) is a standardized redundancy process with a short response time. In the Spanning Tree Protocol (STP protocol), structuring times in the multidigit second range apply in the case of a reorganization of the network structure. These times are reduced to several 100 milliseconds for RSTP.

Real Time

Real time

Redbox

Redundancy box

The Redbox is used for the redundant connection of devices with only one interface to both the LAN A and the LAN B PRP networks. The Redbox is a DAN (Double Attached Node) and operates as a proxy for the devices connected to it (VDAN). The Redbox has its own IP address in order to be able to configure, manage, and monitor it.

Relay Information by OMICRON

Files in RIO format can be used to exchange data between test systems from the OMICRON company and any other project protection planning system. With DIGSI 5 you can export different settings from protection functions in RIO format, which the OMICRON test equipment (XRIO) can then continue to process. The relevant settings are described in the Test Universe manual.

RIO

Data format Relay Information by OMICRON

RSTP

Rapid Spanning Tree Protocol

SAN

Single Attached Node

A SAN is a non-redundant node in the PRP network. It is only connected with one port to one network (LAN A or LAN B). It can only communicate with nodes in the connected network. Via a RedBox, devices with only one connection can be redundantly connected to the 2 LAN A and LAN B networks. In order to obtain symmetrical LAN A and LAN B networks, Siemens recommends avoiding SANs and to connect the devices either via a RedBox or via a separate network without PRP support.

SBO

Select before operate

SC

See Single Command

SCD

See Substation Configuration Description

SCL

Substation Configuration Description Language

SED

System Exchange Description

SEQ

Data Type Sequence

SEQS

DIGSI 5 Test Sequences

Sequence of Events

Acronym: SOE. An ordered, time-stamped log of status changes at binary inputs (also referred to as state inputs). SOE is used to restore or analyze the performance, or an electrical power system itself, over a certain period of time.

Service Interface

Device interface for interfacing DIGSI 5 (for example, through a modem)

SICAM SAS

Substation Automation System – Modularly structured station control system, based on the substation controller SICAM SC and the SICAM WinCC operator control and monitoring system.

SICAM WinCC

The operator control and monitoring system SICAM WinCC graphically displays the state of your network. SICAM WinCC visualizes alarms and messages, archives the network data, provides the option of intervening manually in the process and manages the system rights of the individual employees.

SIM

Simulation data format for single/multiple devices

Simple Network Management Protocol

The Simple Network Management Protocol (SNMP) is an Internet standard protocol and serves for the administration of nodes in an IP network.

Simple Network Time Protocol

The Simple Network Time Protocol (SNTP) is a protocol for the synchronization of clocks via the Internet. With SNTP, client computers can synchronize their clocks via the Internet with a time server.

Simulation data format for single/multiple devices

You can export the simulation-related files of a SIPROTEC 5 device in the SIM format. This new functionality in DIGSI 5 provides the ability to export the simulation data and simulate all the devices in the DIGSI 5 project for test and commissioning needs. The simulation is achieved by importing the simulation file into a signal processing and automation system which will then simulate the device/devices with the process data as in a real-time system. This feature also ensures the testing of a device for various real time system conditions.

Single Command

Single commands (SPC – Single Point Control) are process outputs which visualize 2 process states (for example, On/Off) at an output.

Single-line diagram

A single-line diagram (SLD) is a simplified electric overview of the switchgear. Only 1 phase is shown instead of all 3 phases of a line. Therefore, the diagram is called single-line.

Single-Line Editor

A Single-Line Editor contains a catalog of topological components to create a single-line diagram. The customer may use the single line elements to configure the topological view of his substation.

Single-point indication

Single-point indications (SPS – Single point status) are process indications which visualize 2 process states (for example, On/Off) at an input.

SIPROTEC 5 device

This object type represents a real SIPROTEC device with all the contained setting values and process data.

SIPROTEC

The registered trademark SIPROTEC designates the product family of protection devices and fault recorders.

Slave device

A slave may only exchange data with a master after it has been requested to do so by this master. SIPROTEC devices work as slaves. A master computer controls a slave computer. A master computer can also control a peripheral device.

SLD

Single-line diagram

SLE

Single Line Editor

SNMP

Simple Network Management Protocol

SNTP

Simple Network Time Protocol

SOE

Sequence of Events

SP

See Single-Point Indication

SPC

IEC 61850 data type: Single Point Control

SPS

IEC 61850 data type: Single point status

SSD

System Specification Description

ST

Structured Text file

Station Description

A station description is an IEC 61850-compliant file for data exchange between the system configurator and the IED configurator. The station description contains information on the network structure of a substation. The station description contains for example, information on the assignment of the devices to the primary equipment, as well as on the station-internal communication.

Structured Text file

You can import function charts (CFC) from DIGSI 4 in ST format. First, however, export your function charts from DIGSI 4.87 or higher.

Substation Configuration Description Language

A description language standardized in IEC 61850, SCL is based on XML. This description language allows all information relevant to an IEC 61850 substation to be documented consistently. This format is therefore suitable for exchanging IEC 61850-specific data between different applications, even if these come from different manufacturers. The described import checks are basically done for all SCL formats, not only for SCD imports.

System Exchange Description

Files in SED format can be used to exchange interface information between DIGSI 5 projects and thus between substations. To do this, the project reads in the data for the other projects from the file during import and writes its own data in the same file during export. The contents of an SED file are formulated in SCL.

System Specification Description

Files in SSD format contain the complete specification of a station automation system, including a single-line configuration of the station. The assignment of logical nodes from IEC 61850 to primary equipment can also be described in SSD files. This allows device requirements to be defined in the SSD file so that the devices can be used in the substation. The contents of an SSD file are formulated in SCL.

TAI

Temps Atomique International - International Atomic Time

TC

Tap position command – see Transformer Tap Position Command

TCP

Transmission Control Protocol

TEA-X

You can archive the data from individual SIPROTEC 5 devices or whole project in TEA-X format. This format is also suitable for data exchange between different applications, such as DIGSI 5 and Engineering Base (EB). The TEA-X format is based on XML.

Telephone book

Participant addresses for the modem connection are saved in this object type.

Time stamp

A time stamp is a value in a defined format. The time stamp assigns a time point to an event, for example, in a log file. Time stamps ensure that events can be found again.

Topological view

The Topological View is oriented to the objects of a system (for example, switch gear) and their relation to one another. The Topological View describes the structured layout of the system in hierarchical form. The Topological View does not assign the objects to the devices.

Transmission Control Protocol

The Transmission Control Protocol (TCP) is a transmission protocol for transport services in the Internet. TCP is based on IP and ensures connection of the participants during the data transmission. TCP ensures the correctness of the data and the correct sequence of the data packages.

Transparent Clock

The Precision Time Protocol knows different types of clocks: an ordinary clock (abbreviation: OC), a boundary clock (BC), and a transparent clock (TC). The transparent clock was added to the specification in 2008 and

890

Improves the time synchronization transmission of the network by receiving PTP messages and transmitting them after modification (correction).

Tree view

The left area of the project window visualizes the names and symbols of all containers of a project in the form of a hierarchical tree structure. This area is referred to as a tree view.

Tunneling

Technology for connecting two networks via a third network, whereby the through traffic is completely isolated from the traffic of the third network.

UDP

User Datagram Protocol

Unbuffered Report Control Block

Unbuffered Report Control Block (URCB) is a form of report controlling. Internal events trigger the immediate sending of reports based on best effort. If no association exists or if the transport data flow is not fast enough, events can be lost.

URCB

Unbuffered Report Control Block

USART

Universal Synchronous/Asynchronous Receiver/Transmitter

User Datagram Protocol (UDP)

UDP is a protocol. The protocol is based on IP as TCP. In contrast to this, however, UDP works without a connection and does not have any safety mechanisms. The advantage of UDP in comparison to IP is the higher transmission rate.

UTC

Universal Time Coordinated

Vendor ID

Manufacturer-specific part of the device identification for PROFINET

Virtual Device

A VD (virtual device) comprises all communication objects, as well as their properties and states, which a communication user can utilize in the form of services. A VD can be a physical device, a module of a device or a software module.

WYE

Phase-to-ground related measurements of a 3-phase system

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