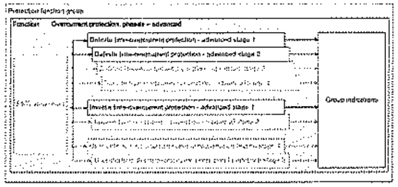

Figure 6-5 Structure/Embedding of the Function Overcurrent Protection, Phases – Advanced

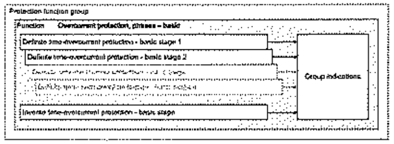

Figure 6-6 Structure/Embedding the Function Overcurrent Protection, Phases – Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with an inrush-current detection function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

6.3.3 Filter for RMS Value Gain

6.3.3.1 Description

The function block Filter can be used to adapt the RMS value for 2 means:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter.
- To only compensate the amplitude attenuation of higher frequencies due to the anti-aliasing filter.

The filter gain (amplitude response) is realized by a 9-order FIR filter.

Logic

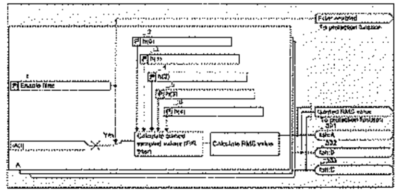

Figure 6-7 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards, the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the values of the respective parameters h(0), h(1), h(2), h(3), and h(4).

NOTE

A FIR-filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block Filter is instantiated and the parameter Enable filter is set as yes. Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Gained RMS measured value of current A	kA	A	Parameter Rated current
Iph:B	Gained RMS measured value of current B	kA	A	Parameter Rated current
Iph:C	Gained RMS measured value of current C	kA	A	Parameter Rated current

You can find the parameter Rated current in the FB General of function groups where the Overcurrent protection, phases – advanced function is used.
If the parameter Enable filter is set to no, the functional measured values are shown as --.

6.3.3.2 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) = -0.007 h(1) = -0.017 h(2) = 0.045 h(3) = -0.110 h(4) = 1.151
60 Hz	h(0) = -0.005 h(1) = -0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

6.3.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Filt new				
_: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

6.3.3.4 Information List

No.	Information	Data Class (Type)	Type
Filt new			
_:301	Filter:Iph:A	MV	O
_:302	Filter:Iph:B	MV	O
_:303	Filter:Iph:C	MV	O

6.3.4 Stage with Definite-Time Characteristic Curve

6.3.4.1 Description

Logic of the Basic Stage

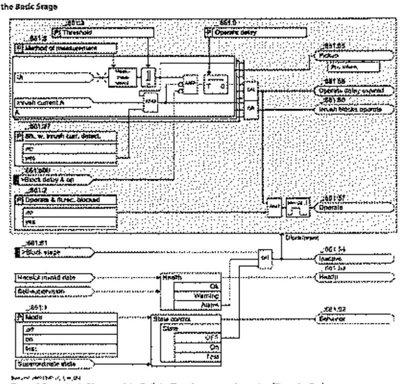

Figure 6-8 Logic Diagram of the Definite Time-Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage

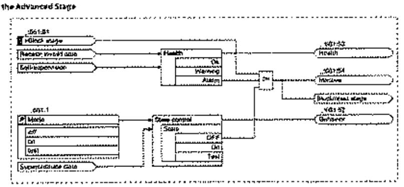

Figure 6-9 Logic Diagram of the Stage Control

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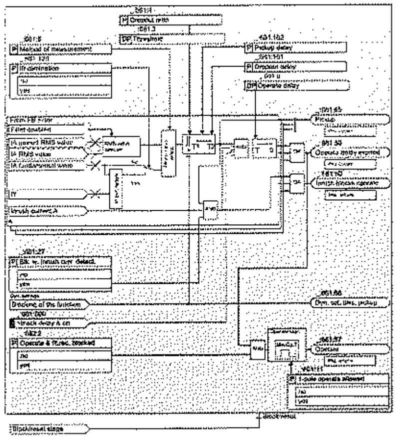

Figure 6-10 Logic Diagram of the Definite Time-Overcurrent Protection (Phases) – Advanced

Method of measurement (Basic and Advanced Stage)

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

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

RMS-Value Selection (Advanced Stage)

If RMS value is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement:

- Normal RMS value
- Gated RMS value from the function block Filter

If the function block Filter is configured and if you have enabled the filter, the gated RMS value is automatically used.

NOTE
When the function block Filter is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the phase-to-phase faults on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection application on one transformer.

In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.

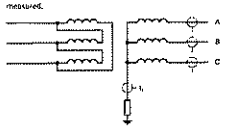

Figure 6-11 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the Voltage/current 1-phase. The function group Voltage/current 1-phase must be connected to the function group Voltage/current 3-phase in which the function Overcurrent protection, phases is being used.

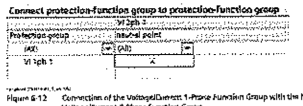

Figure 6-12 Connection of the Voltage/Current 1-Phase Function Group with the Neutral Point Input of the Voltage/Current 3-Phase Function Group

In case of an I0 elimination, the following calculations result:

$I_{A\,elim.} = I_A - 1/3\, I_Y$

$I_{B\,elim.} = I_B - 1/3\, I_Y$

$I_{C\,elim.} = I_C - 1/3\, I_Y$

The phase current $I_{x\,elim.}$ is necessary for the following protection process.

If the Method of measurement parameter is set to fundamental comp., the I0 elimination is applied. The currents $I_{x\,elim.}$ are available as functional values.

Pickup delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay is generated. If the threshold remains exceeded during the pickup delay time, the pickup signal is generated.

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage from an external or internal source
- Via the functionality of the dynamic settings (only available in the Advanced function type, see subtitle Influence of other functions via dynamic settings and chapter 6.3.8.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.3.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic Reclosing
- Cold load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.3.8.1 Description.

6.3.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:661:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than $0.1\, I_{rated,sec}$

Parameter: Threshold, Operate delay

- Default setting (_:661:3) Threshold = 1.500 A (for the 1st stage)
- Default setting (_:661:6) Operate delay = 0.30 s (for the 1st stage)

Set the Threshold and Operate delay parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite time-overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Therefore, set the Threshold parameter for lines to approx. 10 %, for transformers and motors to approx. 20% above the maximum load that is expected.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power

P_{max} = 120 MVA

Correspondingly

I_{max} = 630 A

Current transformer = 600 A/5 A

Safety factor = 1.1

Settings in primary and secondary values result in the setting values:

Threshold value 1st stage (primary) = 1.1 · 630 A = 693 A

Threshold value 1st stage (secondary) $= 1.1 \cdot \frac{630\,A}{600\,A} \cdot 5\,A = 5.8\,A$

The Operate delay to be set is derived from the time-grading schedule that has been prepared for the system.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the Threshold parameter to ensure that the stage does not pick up in case of a short circuit at the end of the line.

Set the Operate delay parameter to 0 or to a low value

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length) = 60 km

Z_1/s = 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: Z_0/Z_1 = 4

Short-circuit power at the beginning of the line:

S_k'' = 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: Z_{0P}/Z_{1P} = 2

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_P:

Z_L = 0.46 Ω/km · 60 km = 27.6 Ω

$$Z_P = \frac{110\ kV^2}{2500\ MVA} = 4.84\ \Omega$$

The 3-phase short-circuit current at the end of the line is $I_{k\,end}$:

$$I_{k\,end} = \frac{1.1 \cdot V_{rated}}{\sqrt{3} \cdot (Z_P + Z_L)} = \frac{1.1 \cdot 110\ kV}{\sqrt{3} \cdot (4.84\ \Omega + 27.6\ \Omega)} = 2150\ A$$

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

Threshold value 2nd stage (primary) = 1.1 · 2150 A = 2365 A

Threshold value 2nd stage (secondary) $= 1.1 \cdot \frac{2150\,A}{600\,A} \cdot 5\,A = 19.7\,A$

If short-circuit currents exceed 2365 A (primary) or 19.7 A (secondary), there is a short circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance and line impedance have different angles, you have to use complex numbers to calculate the Threshold.

Parameter: I0 elimination

- Default setting (_:661:120) I0 elimination = no

This parameter is not visible in the basic stage.

The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the phase-to-phase fault on the transformer low-voltage side. The following conditions must be fulfilled:

- The transformer neutral point current I_Y is measured and is available for the protection function group.
- The parameter Method of measurement is set to fundamental comp..

With the I0 elimination parameter, you can switch the I0 elimination function on or off.

Parameter: Pickup delay

- Default setting (_:661:102) Pickup delay = 0.00 s

This parameter is not visible in the basic stage.

For special applications, it is desirable that a short exceeding of the current threshold does not lead to the pickup of the stage and start fault logging and recording. If this stage is used as a thermal overload function, that is considered a special application.

When using the Pickup delay parameter, a time interval is defined during which a pickup is not triggered if the current threshold is exceeded.

For all short-circuit protection applications, this value is 0.00 s as a default.

Parameter: Dropout delay

- Recommended setting value (_:661:101) Dropout delay = 0.00 s

This parameter is not visible in the basic stage.

Siemens recommends to use the default setting 0 since the dropout of a protection stage must be done as fast as possible.

You can use the Dropout delay parameter ≠ 0 to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: Dropout ratio

- Recommended setting value (_:661:4) Dropout ratio = 0.95

This parameter is not visible in the basic stage.

The recommended set value of 0.95 is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter Dropout ratio can be reduced, for example, to 0.98. If you expect highly fluctuating measurands at the response threshold, you can increase the setting value of the parameter Dropout ratio. This avoids chattering of the tripping stage.

Parameter: 1-pole operate allowed

- Default setting (_:661:11) 1-pole operate allowed = no

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group Circuit-breaker) is always 3-pole because the device does not support phase-selective tripping.

6.3.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:661:1	Definite-T 1:Mode		• off • on • test	off
_:661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:661:11	Definite-T 1:1-pole operate allowed		• no • yes	no
_:661:26	Definite-T 1:Dynamic settings		• no • yes	no
_:661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:661:120	Definite-T 1:I0 elimination		• no • yes	no

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Addr.	Parameter	C	Setting Options	Default Setting
_:661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:661:102	Definite-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:661:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:661:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:661:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:661:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:661:36	Definite-T 1:Stage blocked		• no • yes	no
_:661:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:661:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:661:37	Definite-T 1:Stage blocked		• no • yes	no
_:661:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:661:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:661:38	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:661:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:661:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:661:39	Definite-T 1:Stage blocked		• no • yes	no
_:661:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:661:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:661:40	Definite-T 1:Stage blocked		• no • yes	no
_:661:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:661:34	Definite-T 1:Effected by binary input		• no • yes	no
_:661:41	Definite-T 1:Stage blocked		• no • yes	no
_:661:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:661:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.3.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:661:81	Definite-T 1:>Block stage	SPS	[illegible]
_:661:84	Definite-T 1:>Activ. dyn. settings	SPS	[illegible]
_:661:500	Definite-T 1:>Block delay & op.	SPS	[illegible]
_:661:54	Definite-T 1:Inactive	SPS	O
_:661:52	Definite-T 1:Behavior	ENS	O
_:661:53	Definite-T 1:Health	ENS	O
_:661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:661:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:661:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:661:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:661:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:661:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:661:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:661:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:661:55	Definite-T 1:Pickup	ACD	O
_:661:56	Definite-T 1:Operate delay expired	ACT	O
_:661:57	Definite-T 1:Operate	ACT	O
_:661:302	Definite-T 1:Del.Ipls	WYE	O

6.3.5 Stage with Inverse-Time Characteristic Curve

6.3.5.1 Description

Logic of the Basic Stage

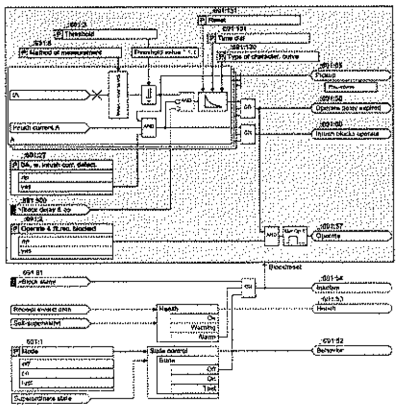

Figure 6-13 Logic Diagram of the Inverse Time-Overcurrent Protection (Phases) – Basic

Logic of the Advanced Stage

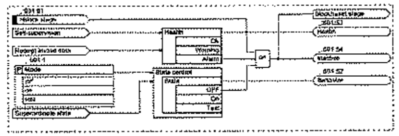

Figure 6-14 Logic Diagram of the Stage Control

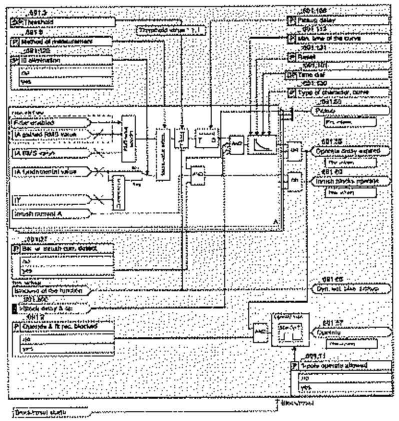

Figure 6-15 Logic Diagram of the Inverse Time-Overcurrent Protection (Phases) – Advanced

RMS-Value Selection (Advanced Stage)

If RMS value is selected as the method of measurement, the protection function supports 2 kinds of RMS measurement.

- Normal RMS value
- Gained RMS value from the function block Filter

If the function block Filter is configured and if you set parameter _:IG_OCP_Inverse time_Advanced_1...en_US have enabled the filter, the gained RMS value is automatically used.

> **NOTE**
> When the function block Filter is applied, only one 3-phase current measuring point is allowed to be connected to the 3-phase current interface of the function group.

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Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

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

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

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

Minimum Time of the Curve (Advanced Stage)

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.

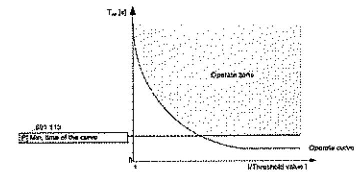

Figure 6-16 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Method of Measurement (Basic and Advanced Stage)

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

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

I0 Elimination (Advanced Stage)

In order to increase the sensitivity for the phase-to-phase faults on the transformer low-voltage side, use the I0 elimination of the phase currents for the overcurrent-protection applications on one transformer.
In order to determine the I0 elimination of the phase currents, the transformer neutral point current I_Y must be measured.

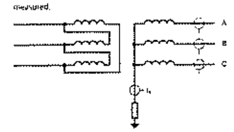

Figure 6-17 I0 Elimination Principle

The transformer neutral point current I_Y is measured via a 1-phase current measuring point that is connected to the Voltage/current 1-phase. The function group Voltage/current 1-phase must be connected to the function group Voltage/current 3-phase in which the function Overcurrent protection, phases is used.

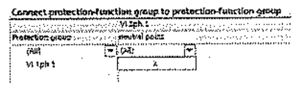

Figure 6-18 Connection of the Function Group Voltage/Current 1-Phase with the Neutral Point Input of the Voltage/Current 3-Phase Function Group

In case of an I0 elimination, the following calculations must be considered:

$I_{A\text{-}elim} = I_A - 1/3\, I_Y$
$I_{B\text{-}elim} = I_B - 1/3\, I_Y$
$I_{C\text{-}elim} = I_C - 1/3\, I_Y$

The phase current $I_{x,elim}$ is necessary for the following protection process.
If the Method of measurement parameter is set to fundamental comp., the I0 elimination is operating.
The currents $I_{xx,elim}$ are available as functional values.

Pickup Delay (Advanced Stage)

If the current exceeds the threshold value, the pickup delay starts. If the threshold is exceeded during the pickup delay time, the pickup signal is generated.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage from an external or internal source
- Via the functionality of the dynamic settings (only available in the Advanced function type, see subtitle Influence of other functions via dynamic settings and chapter 6.3.8.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter [illegible] Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent protection stages:

- Automatic Reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.3.8.1 Description.

6.3.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:691:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 I_{rated}.

Parameter: Type of character. curve

- Default setting (_:691:130) Type of character. curve = IEC normal inverse

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

Parameter: Min. time of the curve

- Default setting (_:691:113) Min. time of the curve = 0.00 s

This parameter is only available in the advanced stage.
With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of the inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.
This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

> **NOTE**
> If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting (_:691:115) Additional time delay = 0.00 s

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay.
If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic time.
This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: Threshold

- Default setting (_:691:3) Threshold = 1.500 A

Set the Threshold and Type of character. curve parameters for the specific application.
The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection. Set the Threshold parameter for lines to approx. 10 %, for transformers and motors to approx. 20 % above the maximum expected load.
Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the Threshold.

EXAMPLE

Overcurrent-protection stage: 110-kV overhead line, 150 mm² cross-section

Maximum transmittable power
P_{max} = 120 MVA
Correspondingly
I_{max} = 630 A
Current transformer = 600 A/5 A

Settings in primary and secondary values result in the setting values:
Threshold value I> (primary) = 630 A

$$\text{Threshold value I> (secondary)} = \frac{630\,A}{600\,A} \cdot 5\,A = 5.25\,A$$

Parameter: I0 elimination

- Default setting (_:661:120) I0 elimination = no

This parameter is not visible in the basic stage.
The I0 elimination in phase currents for overcurrent-protection applications can be used in a transformer. This increases the sensitivity for the phase-to-phase faults on the low voltage side of the transformer. The following conditions must be fulfilled:

- The transformer neutral point current I_Y is measured and is available for the protection function group.
- The parameter Method of measurement is set to fundamental comp..

With the I0 elimination setting, you can switch the I0 elimination function on or off.

Parameter: Pickup delay

- Default setting (_:661:107) Pickup delay = 0.00 s

This parameter is not visible in the basic stage.
For special applications it is desirable if the current threshold is briefly exceeded, that this will not lead to the pickup of the stage and starts fault logging or recording. If this stage is used as a thermal overload function, that is considered a special application.
When using the Pickup delay parameter, a time interval is defined during which a pickup is not trigger if the current threshold is exceeded.
For all short-circuit protection applications, this value is 0.00 s and is considered as a default

Parameter: Time dial

- Default setting (_:691:101) Time dial = 1.00

Use the Time dial parameter to displace the characteristic curve in the time direction.
The set value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system.
Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter Time dial at 1 (default setting).

Parameter: Reset

- Default setting (_:691:131) Reset = disk emulation

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

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

Parameter: 1-pole operate allowed

- Default setting (_:691:11) 1-pole operate allowed = no

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase selectively. However, tripping by the device (generated in the tripping logic of the function group Circuit-breaker) is always 3-pole because the device does not support phase-selective tripping.

6.3.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:691:1	Inverse-T 1:Mode		• off • on • test	off
_:691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:691:11	Inverse-T 1:1-pole operate allowed		• no • yes	no
_:691:26	Inverse-T 1:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:691:120	Inverse-T 1:I0 elimination		• no • yes	no
_:691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:108	Inverse-T 1:Pickup delay		0.00 s to 60.00 s	0.00 s
_:691:130	Inverse-T 1:Type of character. curve			
_:691:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:691:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:691:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:691:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:691:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:691:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:691:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:691:36	Inverse-T 1:Stage blocked		• no • yes	no
_:691:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:691:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:691:37	Inverse-T 1:Stage blocked		• no • yes	no

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Addr.	Parameter	C	Setting Options	Default Setting
_:691:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:691:31	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:691:38	Inverse-T 1:Stage blocked		• no • yes	no
_:691:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s.: AR cycle>3				
_:691:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:691:39	Inverse-T 1:Stage blocked		• no • yes	no
_:691:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s.: Cold load PU				
_:691:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:691:40	Inverse-T 1:Stage blocked		• no • yes	no
_:691:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:691:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:691:41	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:691:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:691:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.3.5.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:691:81	Inverse-T 1:>Block stage	SPS	I
_:691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:691:54	Inverse-T 1:Inactive	SPS	O
_:691:52	Inverse-T 1:Behavior	ENS	O
_:691:53	Inverse-T 1:Health	ENS	O
_:691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:691:59	Inverse-T 1:Disk emulation running	SPS	O
_:691:55	Inverse-T 1:Pickup	ACD	O
_:691:56	Inverse-T 1:Operate delay expired	ACT	O
_:691:57	Inverse-T 1:Operate	ACT	O

6.3.6 Stage with User-Defined Characteristic Curve

6.3.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced stage** (see chapter 6.3.5.1 Description). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

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

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

When the input variable exceeds the threshold value by 1.1 times, the characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 x 1.1 x threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The

dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

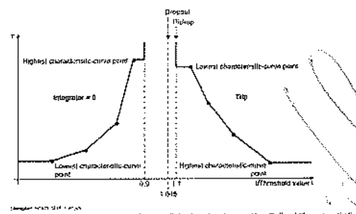

Figure 6-19 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

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

6.3.6.2 Application and Setting Notes

This stage is structured the same way as the **Inverse time-overcurrent protection – advanced stage**. The only difference is that you can define the characteristic curve as desired. This chapter provides only application and setting notes for setting characteristic curves.

Parameter: Current/time value pairs (from the operate curve)

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

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

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

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

Use the **Time dial** parameter to displace the characteristic curve in the time direction.

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

Parameter: Reset

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

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

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation but an instantaneous dropout is desired.

Parameter: Current/time value pairs (of the dropout characteristic curve)

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

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

Set the time value in seconds. The characteristic curve is shifted via the **Time dial** parameter.

NOTE

The value pairs must be entered in continuous order.

Parameter: 1-pole operate allowed

- Default setting (_:111) 1-pole operate allowed = no

The parameter must be set for the specific application.

Parameter Value	Description
no	The stage always operates 3-pole.
yes	The stage operates phase-selectively. However, tripping by the device (generated in the tripping logic of the function group Circuit breaker) is always 3-pole because the device does not support phase-selective tripping.

6.3.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:11	User curve #:1-pole operate allowed		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:120	User curve #:3I0 elimination		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:111	User curve #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s.: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.rdy		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s.: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s.: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

ВЯРНО С ОРИГИНАЛА

Т и Н Енерджи ВАРНА VARNA T & N Energy

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6.3.6.4 Information List

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

6.3.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.3.7.1 Description

With the Blk. w. inrush curr. detect. parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the tripping delay and the trip signal are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates. The following figure only shows the part of the stage (exemplified by definite-time overcurrent protection stage 1) that illustrates the influence of the blocking. Only if the central function Inrush-current detection (see chapter 12.10 Inrush-Current Detection) is in effect can the blocking be set.

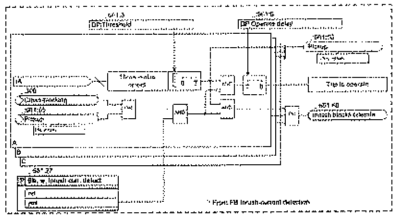

Figure 6-20 Part Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite-Time Overcurrent Protection Stage

6.3.7.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:661:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: ▪ In cases where the device is not used on transformers. ▪ In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_{sc} of the transformer that it only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.3.8 Influence of Other Functions via Dynamic Settings

6.3.8.1 Description

The parameters Threshold and Operate delay used for tripping are so-called dynamic settings. Depending on other functions, the settings of these parameters can be changed dynamically (see

Figure 6-21). Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.

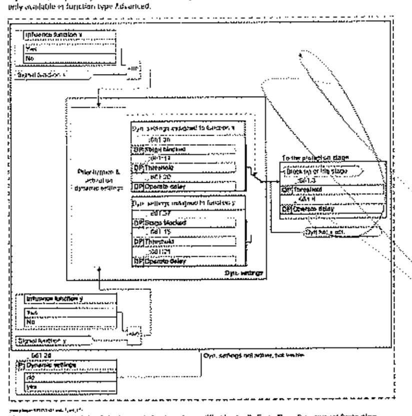

Figure 6-21 Principle of the Dynamic Settings Exemplified by 1st Definite-Time Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent protection stages:

Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings of the Threshold and Operate delay parameters are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter Influence of function ... and its own dynamic settings (Operate delay and Threshold). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for

example, signal function x) becomes active and is to take effect, these settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

Where several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 2 precedes that of priority 3. The settings assigned to signal 2 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Automatic Reclosing (Advanced Stage)*

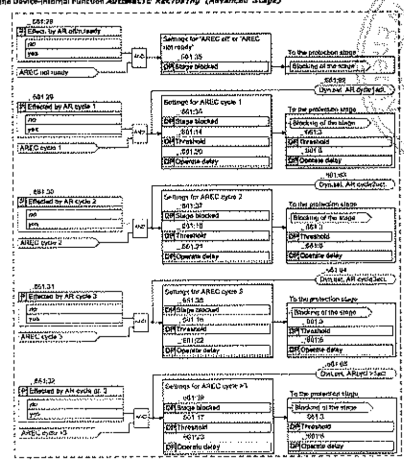

Figure 6-22 Influence of the AREC Signals on the Overcurrent-Protection Stage

Several AREC signals can affect the setting for the Threshold and Operate delay parameters of the protection stage and its blocking.

- AREC is ready for reclosing 1 (= Automatic reclosing cycle 1)
- AREC is ready for reclosing 2 (= Automatic reclosing cycle 2)
- AREC is ready for reclosing 3 (= Automatic reclosing cycle 3)
- AREC is ready for reclosing 4 (= Automatic reclosing cycle >3)

The following signal can only block the protection stage:

- AREC is not ready or switched off (= Automatic reclosing off / not ready)

This means that if the AREC is ready and the protection stage is in the idle state, the settings for AREC cycle 1 are active and not the standard settings. The standard settings are active in the case of AREC off/not ready.

The influence can be activated for each signal individually. You also have to set the Threshold and Operate delay or Stage blocked parameters, which take effect when the signal is active.

The way AREC signals are generated is described in chapter 6.47.1 Overview of Functions.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*

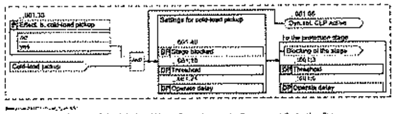

Figure 6-23 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

In the case of cold-load pickup, you have the option to change the settings for the Threshold and Operate delay parameters of the protection level. You can also block the level. To do so, you must activate the influence of the cold-load pickup. You also have to set the Threshold and Operate delay or assign settings to Stage blocked, which take effect when the signal is active.

The way signals are generated Cold-load pickup is described in chapter 5.6.1 Overview of Functions.

Link to an External *Function via a Binary Input Signal (Advanced Stage)*

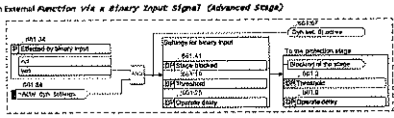

Figure 6-24 Influence of the Binary Input on the Overcurrent Protection Stage

You can use the binary input signal >Activ. dyn. settings to change the settings for the Threshold and the Operate delay parameters of the protection stage. You can also block the level. To do so, you must activate the influence of the binary input. You also have to set the Threshold and Operate delay or assign settings to Stage blocked, which take effect when the signal is active.

6.3.8.2 Application and Setting Notes (Advanced Stage)

Parameter: Dynamic settings

- Default setting (_:661:28) Dynamic settings = no

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (automatic reclosing function or cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to yes. This makes the configuration parameters Influence of function... as well as the dynamic settings Threshold, Operate delay and Stage blocked of the stage visible and enables the settings to be set for the specific influence.

Influence of AREC

The example of how the overcurrent stage (1st stage) can be used as a fast stage before automatic reclosing describes the influence exerted by AREC.

The setting of the overcurrent stage (1st stage) results from the time-grading schedule. Additionally, it is to be used as fast stage before an automatic reclosing. Because a fast disconnection of the short-circuit current takes priority over the selectivity prior to reclosing, the tripping delay can be set to 0 or a very small value. To achieve the selectivity, the final disconnection must be done with the grading time.

AREC is set to 2 reclosings. A secondary Threshold of 1.5 A and a Operate delay of 600 ms are assumed (according to the time grading schedule) for the overcurrent-protection stage. The standard settings of the stage are set to these values.

To realize the application, the configuration settings Effected by AR cycle 1 and Effected by AR cycle 2 are changed in the example to yes (= influenced). This activates the AR cycle 1 and AR cycle 2 input signals within the stage. When they become active, they switch to the assigned dynamic settings.

The two dynamic settings Operate delay assigned to these input signals (sources of influence) are set to the time delay 0 (instantaneous tripping). The two dynamic settings Threshold assigned to these input signals are set to the normal threshold value of 1.5 A.

If the threshold value (1.5 A) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of 600 ms according to the time grading schedule.

Influence of External Devices

The influence of an external device can also be configured. The above is an example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing, in which case the AREC function is performed by an external device.

To realize the application, the configuration setting Effected by binary input must be changed to yes (= influenced). This activates the >Activ. dyn. settings input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings. The external device must provide the Cycle 1 and Cycle 2 signals or, alternatively, the AR ready signal. The signals must be connected with the binary input signal >Activ. dyn. settings.

The dynamic setting Operate delay which is assigned to the input signal (source of influence) >Activ. dyn. settings, is set to the time delay 0 (instantaneous tripping). The dynamic setting Threshold assigned to this input signal is set to the normal threshold value of 1.5 A.

If the threshold value (1.5 A) is exceeded before AREC 1 and AREC 2, the overcurrent protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of 600 ms according to the time grading schedule.

6.4 Voltage-Dependent Overcurrent Protection, Phases

6.4.1 Overview of Functions

The Voltage-dependent overcurrent protection (ANSI 51V) function:

- Detects short circuits affecting electric equipment
- Can be used for special network conditions where the overcurrent pickup level should be decreased depending on the fault voltage
- Can be used for generators where the excitation voltage is derived from the machine terminals and the overcurrent pickup should be kept depending on the fault voltages

6.4.2 Structure of the Function

The Voltage-dependent overcurrent protection function is used in protection function groups with 3-phase current and voltage measurement.

The function Voltage-dependent overcurrent protection comes with the following factory-set stages:

- Inverse time-overcurrent protection, voltage-dependent stage
- Definite time-overcurrent protection, undervoltage seal-in stage

In this function, the following stages can operate simultaneously:

- A maximum of 2 inverse time-overcurrent protection, voltage-dependent stages
- A maximum of 2 inverse time-overcurrent protection, voltage-released stages
- A maximum of 2 definite time-overcurrent protection, undervoltage seal-in stages
- A maximum of 2 definite time-overcurrent protection, voltage-released undervoltage seal-in stages

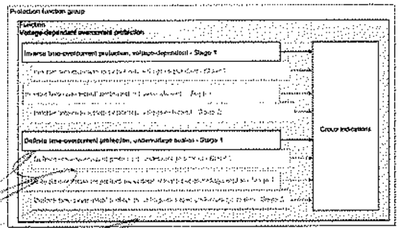

Figure 6-25 Structure/Embedding of the Function

6.4.3 Stage with Inverse Time-Overcurrent Protection, Voltage-Dependent

6.4.3.1 Description

Logic of the Stage

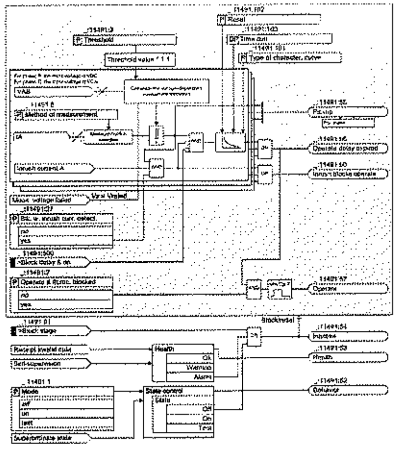

Figure 6-26 Logic Diagram of the Inverse Time-Overcurrent Protection, Voltage-Dependent

Method of Measurement

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

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

Voltage-Dependent Pickup Threshold

The pickup threshold of the overcurrent stage depends on the voltage magnitude. A lower voltage decreases the current pickup value (see Figure 6-27). In the range between V/V_{rated} = 1.00 to 0.25 a linear, directly proportional dependence is realized.

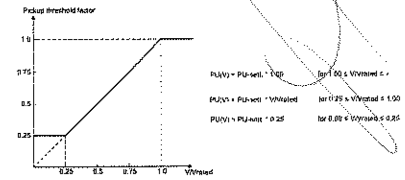

Figure 6-27 Voltage Influence of the Pickup Threshold

With:

V	-	Measured phase-to-phase voltage
V_{rated}	-	Rated voltage (parameter Rated voltage in the function block General of the protection function group)
PU sett.	-	Pickup threshold setting (parameter address: _:11491:3)
PU(V)	-	Applied pickup threshold according to the voltage influence

The minimum current pickup threshold value is 0.03 * Irated. This value cannot be decreased any further even not by voltage-dependent pickup threshold factor.

Decreasing the pickup threshold is carried out phase-selectively. The assignment of voltages to current-carrying phases is shown in Table 6-1.

Table 6-1 Controlling Voltages in Relation to the Fault Current

Current	Controlling Voltage
I_A	V_{AB}
I_B	V_{BC}
I_C	V_{CA}

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

When the input variable exceeds the threshold value by a factor of 1.1, the inverse-time characteristic curve is processed.

An integrating method of measurement totalizes the weighted time. The weighted time results from the characteristic curve. For this, the time that is associated with the present current value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

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

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

Influence On the Operate Curve

The current pickup threshold is decreased proportional to the voltage decrease. Consequently, for a constant current I the I/Threshold-value ratio is increased and the operate time is reduced. Compared with the standard curves represented in the Technical Data, the operate curve shifts to the left side as the voltage decreases.

Measuring-Voltage Failure Detection

In case of a measuring-voltage failure detection the input voltage value is automatically set to V_{rated}, so that the pickup threshold factor will be 1.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

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

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.3.7.1 Description .

6.4.3.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:11491:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer-inrush current cannot become larger than the maximum transmittable short circuit current.
yes	When the transformer inrush current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Method of measurement

- Recommended setting value (_:11491:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).

Parameter: Threshold

- Default setting (_:11491:3) Threshold = 1.500 A

The recommended setting value of 1.500 A is suitable for most applications.

Set the Threshold and Type of character. curve parameters for the specific application.

The setting depends on the maximum occurring operating current. Pickup by overload must be excluded since overcurrent protection operates with short tripping times as short-circuit protection and not as overload protection.

Set the Threshold parameter for lines to approx. 10 %, for transformers and motors to approx. 20 % above the maximum expected load.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the Threshold.

Parameter: Type of character. curve

- Default setting (_:11491:101) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application.

Parameter: Reset

- Default setting (_:11491:102) Reset = disk emulation

The Reset parameter allows you to define whether the stage decreases according to the dropout characteristic curve (behavior of a disk emulation = rotor disc) or instantaneously.

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

Parameter: Time dial

- Default setting (_:11491:103) Time dial = 1

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

The setting value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter Time dial at 1 (default setting).

6.4.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-dependent 1				
_:11491:1	V-dependent 1:Mode		• off • on • test	off
_:11491:2	V-dependent 1:Operate & flt.rec. blocked		• no • yes	no
_:11491:27	V-dependent 1:Blk. w. inrush curr. detect.		• no • yes	no
_:11491:8	V-dependent 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:11491:3	V-dependent 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:11491:101	V-dependent 1:Type of character. curve			
_:11491:102	V-dependent 1:Reset		• instantaneous • disk emulation	disk emulation
_:11491:103	V-dependent 1:Time dial		0.05 to 15.00	1.00

6.4.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
V-dependent 1			
_:11491:81	V-dependent 1:>Block stage	SPS	I
_:11491:500	V-dependent 1:>Block delay & op.	SPS	I
_:11491:54	V-dependent 1:Inactive	SPS	O
_:11491:52	V-dependent 1:Behavior	ENS	O
_:11491:53	V-dependent 1:Health	ENS	O
_:11491:60	V-dependent 1:Inrush blocks operate	ACT	O
_:11491:59	V-dependent 1:Disk emulation running	SPS	O
_:11491:55	V-dependent 1:Pickup	ACD	O
_:11491:56	V-dependent 1:Operate delay expired	ACT	O
_:11491:57	V-dependent 1:Operate	ACT	O

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6.4.4 Stage with Inverse Time-Overcurrent Protection, Voltage-Released

6.4.4.1 Description

Logic of the Stage

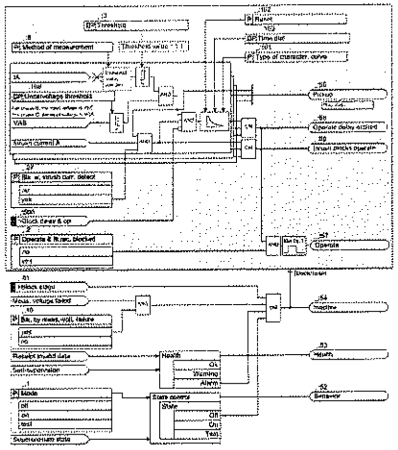

Figure 6-28 Logic Diagram of the Inverse Time-Overcurrent Protection, Voltage-Released

This stage is structured in the same way as the inverse time-overcurrent, voltage-dependent stage (see chapter 6.4.3.1 Description). The only differences are the conditions for the pickup and the influence on the operate curve.

Measuring-Element Release

When the controlling voltage drops below the setting Undervoltage threshold, the respective measuring element is released.

The release of the measuring elements is carried out phase selectively. The assignment of voltages to current carrying phases is shown in Figure 6-27.

Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In case of a blocking, the picked up stage is reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Volt.-transf. c. b., which links in the tripping of the voltage-transformer circuit breaker

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

6.4.4.2 Application and Setting Notes

This stage is structured in the same way as the inverse time-overcurrent, voltage-dependent stage. The only differences are the conditions for the pickup and the influence on the operate curve. This chapter only provides the application and setting notes for the setting Blk. by meas.-volt. failure and Undervoltage threshold. For guidance on the other parameters of this stage, refer to chapter 6.4.3.2 Application and Setting Notes.

Parameter: Blk. by meas.-volt. failure

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

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

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

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

Parameter Value	Description
no	The overcurrent protection stage is not blocked when a measuring voltage failure is detected.
yes	The overcurrent protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct operation of the stage cannot be guaranteed if a measuring-voltage failure occurs.

Parameter: Undervoltage threshold

- Default setting (_:104) Undervoltage threshold = 75.0 V

When the controlling voltage is below the set value, the inverse time-overcurrent stage is released.

The parameter is set to a value just below the lowest phase-to-phase voltage admissible during operation, for example, from 75 % to 80 % of V_{rated}.

6.4.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-release #				
_:1	V release #:Mode		• off • on • test	off
_:2	V release #:Operate & flt.rec. blocked		• no • yes	no
_:10	V release #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	V release #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	V-release #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	V-release #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:101	V-release #:Type of character. curve		• ANSI long-time inv. • ANSI short-time inv. • ANSI extremely inv. • ANSI very inverse • ANSI normal inverse • ANSI moderately inv. • ANSI definite inverse • IEC normal inverse • IEC very inverse • IEC extremely inv. • IEC long time inverse	IEC normal inverse
_:102	V-release #:Reset		• instantaneous • disk emulation	disk emulation
_:103	V-release #:Time dial		0.05 to 15.00	1.00
_:104	V release #:Undervoltage threshold		0.300 V to 175.000 V	75.000 V

6.4.4.4 Information List

No.	Information	Data Class (Type)	Type
V-release #			
_:81	V-release #:>Block stage	SPS	I
_:500	V-release #:>Block delay & op.	SPS	I
_:54	V release #:Inactive	SPS	O
_:52	V-release #:Behavior	ENS	O
_:53	V-release #:Health	ENS	O
_:60	V-release #:Inrush blocks operate	ACT	O
_:59	V release #:Disk emulation running	SPS	O
_:55	V-release #:Pickup	ACD	O
_:56	V-release #:Operate delay expired	ACT	O
_:57	V-release #:Operate	ACT	O

6.4.5 Stage with Definite Time-Overcurrent Protection, Undervoltage Seal-In

6.4.5.1 Description

Logic of the Stage

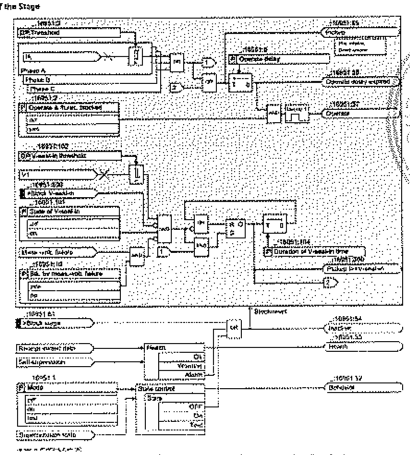

Figure 6-29 Logic Diagram of the Definite Time-Overcurrent Protection, Undervoltage Seal-In

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the operate threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short-circuit fault.

The pickup signal is maintained for a settable seal-in time Duration of V-seal-in time, if the positive-sequence voltage falls below a settable threshold V-seal-in threshold after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input >Block V-seal-in, the signal Pickup I>+V-seal-in drops out immediately.

You can switch off the undervoltage seal-in via the parameter State of V-seal-in.

Blocking of the Undervoltage Seal-In with Measuring Voltage Failure

The Undervoltage seal-in can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal Pickup I>+V-seal-in drops out immediately. The following blocking options are available for the Undervoltage seal-in.

- From an internal source upon pickup of the Measuring-voltage failure detection function.
- From an external source via the binary input signal >Open of the function block VT miniature CB, which links in the tripping of the voltage-transformer circuit breaker.

The parameter Blk. by meas.-volt. failure can be used to control the measuring-voltage failure detection. The Undervoltage seal-in remains unaffected if the parameter Blk. by meas.-volt. failure is switching off.

6.4.5.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:16951:2) Operate & flt.rec. blocked = no

With the parameter Operate & flt.rec. blocked, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting (_:16951:3) Threshold = 1.350 A

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the Threshold parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

- Default setting (_:16951:6) Operate delay = 3.00 s

The parameter Operate delay must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

- Default setting (_:16951:10) Blk. by meas.-volt. failure = yes

With the parameter Blk. by meas.-volt. failure, you can activate (yes) or deactivate (no) the blocking by the Measuring voltage failure detection function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting (_:16951:101) State of V-seal-in = off

With the parameter State of V-seal-in, the seal-in functionality can be activated (switched on). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: V-seal-in threshold

- Default setting (_:16951:102) V-seal-in threshold = 46.2 V

The V-seal-in threshold (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	1.4 * $I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	0.8 * $V_{rated, Gen}$		
Duration of V seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, CT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, CT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{rated, Gen}}{I_{rated, CT, prim}} \times I_{rated, CT, sec} = \frac{1.4 \times 483\ A}{500\ A} \times 1\ A = 1.35\ A$$

$$\text{Undervoltage seal-in} = \frac{0.8 \times V_{rated, Gen}}{V_{rated, VT, prim}} \times \frac{V_{rated, VT, sec}}{\sqrt{3}} = \frac{0.8 \times 6.3\ kV}{6.3\ kV} \times \frac{100\ V}{\sqrt{3}} = 46.200\ V$$

Parameter: Duration of V-seal-in time

- Default setting (_:16951:104) Duration of V-seal-in time = 4.00 s

The parameter Duration of V-seal-in time limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter Operate delay. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

6.4.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V-seal-in 1				
_:16951:1	V seal-in 1:Mode		• off • on • test	off
_:16951:2	V-seal-in 1:Operate & flt.rec. blocked		• no • yes	no
_:16951:3	V-seal-in 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.75 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:16951:6	V seal-in 1:Operate delay		0.00 s to 60.00 s	3.00 s
_:16951:10	V seal-in 1:Blk. by meas.-volt. failure		• no • yes	yes

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Addr.	Parameter	C	Setting Options	Default Setting
_:16951:101	V-seal-in 1:State of V-seal-in		• off • on	off
_:16951:102	V-seal-in 1:V-seal-in threshold		0.300 V to 175.000 V	69.019 V
_:16951:104	V-seal-in 1:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s

6.4.5.4 Information List

No.	Information	Data Class (Type)	Type
V-seal-in 1			
_:16951:81	V-seal-in 1:>Block stage	SPS	I
_:16951:500	V-seal-in 1:>Block V-seal-in	SPS	I
_:16951:52	V-seal-in 1:Behavior	ENS	O
_:16951:53	V-seal-in 1:Health	ENS	O
_:16951:54	V-seal-in 1:Inactive	SPS	O
_:16951:55	V-seal-in 1:Pickup	ACD	O
_:16951:300	V-seal-in 1:Pickup I>+V-seal-in	SPS	O
_:16951:56	V-seal-in 1:Operate delay expired	ACT	O
_:16951:57	V-seal-in 1:Operate	ACT	O

6.4.6 Stage with Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-In

6.4.6.1 Description

Logic of the Stage

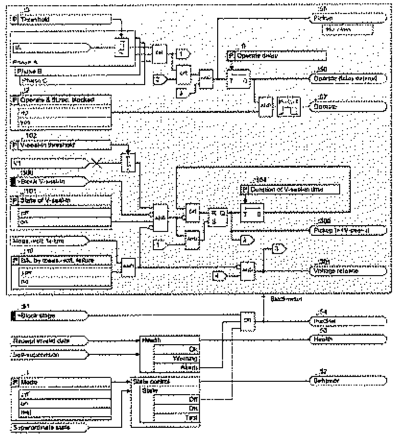

Figure 6-30 Logic Diagram of the Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-In, Part 1

Signal 4 in the following figure refers to Figure 6-30.

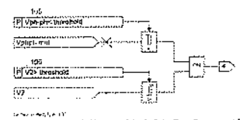

Figure 6-31 Logic Diagram of the Definite Time-Overcurrent Protection, Voltage-Released Undervoltage Seal-In, Part 2

Voltage Release

In addition to the current criterion with undervoltage seal-in, a voltage released logic must be present to issue the indication *Pickup*. The voltage released logic monitors the negative sequence voltage and phase to phase voltages respectively for detecting unsymmetrical faults and symmetrical faults. With the voltage-released logic, the setting value of the parameter Threshold can be reduced in a certain range and the reliability and sensibility of this function can be improved correspondingly.

Undervoltage Seal-In

In generators where the excitation voltage is derived from the machine terminals, the short-circuit current decreases quickly in the event of close-in faults (for example, in a generator or a generator-transformer range). The current decreases to a value below the current threshold within a few seconds because of the absence of the excitation voltage. To avoid a dropout of the relay, the positive-sequence voltages are used as an additional criterion for detecting a short-circuit fault.

The pickup signal is maintained for a settable seal-in time Duration of V-seal-in time, if the positive-sequence voltage falls below a settable threshold V-seal-in threshold after an overcurrent pickup, even if the current falls below the threshold again. If the voltage recovers before the seal-in time has elapsed, or if the undervoltage seal-in is blocked via a binary input >Block V-seal-in, the signal *Pickup I>+V-seal-in* drops out immediately.

You can switch off the undervoltage seal-in via the parameter State of V-seal-in.

Blocking of the Undervoltage Seal-In with Measuring-Voltage Failure

The Undervoltage seal-in can be blocked if a measuring-voltage failure occurs. In case of a blocking, the pickup signal *Pickup I>+V-seal-in* drops out immediately. The following blocking options are available for the Undervoltage seal-in:

- From an internal source upon pickup of the **Measuring-voltage failure detection** function.
- From an external source via the binary input signal *>Open* of the function block **VT miniature CB**, which links in the tripping of the voltage-transformer circuit breaker.

The parameter Blk. by meas.-volt. failure can be used to control the measuring-voltage failure detection. The **Undervoltage seal-in** remains unaffected if the parameter Blk. by meas.-volt. failure is switched off.

6.4.6.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

With the parameter Operate & flt.rec. blocked, you can block the operate indication, the fault recording, and the fault log.

Parameter: Threshold

- Default setting (_:3) Threshold = 1.350 A

The setting is mainly determined by the maximum operating current.

Pickup by overload must be excluded since the protection may trip if a short operate delay time is set. Set the Threshold parameter for generators to a value between 20 % and 30 %, for transformers and motors approx. 40 % above the expected peak load.

Parameter: Operate delay

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

The parameter Operate delay must be coordinated with the time grading of the network protection to guarantee the selectivity. Practical time delays are between 1 s to 2 s.

Parameter: Blk. by meas.-volt. failure

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

With the parameter Blk. by meas.-volt. failure, you can activate (yes) or deactivate (no) the blocking by the Measuring-voltage failure detection function. The recommended setting is the default setting.

Parameter: State of V-seal-in

- Default setting (_:101) State of V-seal-in = off

With the parameter State of V-seal-in, the seal-in functionality can be activated (switched on). Siemens recommends this setting if the excitation transformer is connected to the main lead of the generator.

Parameter: V-seal-in threshold

- Default setting (_:102) V-seal-in threshold = 46.2 V

The V-seal-in threshold (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during an operation, for example 80 % of the rated voltage of a generator. The positive-sequence voltage is evaluated. The practicable value for a voltage transformer with a rated secondary voltage of 100 V is 46.2 V.

The following table shows an example of a specification:

Threshold	$1.4 * I_{rated, Gen}$		
Operate delay	3.00 s		
Undervoltage seal-in	$0.8 * V_{rated, Gen}$		
Duration of V-seal-in time	4.00 s		
Dropout ratio	0.95		
Rated current $I_{rated, Gen}$	483 A	Rated voltage $V_{rated, Gen}$	6.3 kV
Rated current $I_{rated, VT, prim}$	500 A	Rated voltage $V_{rated, VT, prim}$	6.3 kV
Rated current $I_{rated, VT, sec}$	1 A	Rated voltage $V_{rated, VT, sec}$	100 V

The following secondary setting values result from this specification:

$$\text{Threshold} = \frac{1.4 \times I_{rated, Gen}}{I_{rated, CT, prim}} \times I_{rated, CT, sec} = \frac{1.4 \times 483\ A}{500\ A} \times 1\ A = 1.35\ A$$

$$\text{Undervoltage seal-in} = \frac{0.8 \times V_{rated, Gen}}{V_{rated, VT, prim}} \times \frac{V_{rated, VT, sec}}{\sqrt{3}} = \frac{0.8 \times 6.3\ kV}{6.3\ kV} \times \frac{100\ V}{\sqrt{3}} = 46.200\ V$$

Parameter: Duration of V-seal-in time

- Default setting (_:104) Duration of V-seal-in time = 4.00 s

The parameter Duration of V-seal-in time limits the pickup seal-in induced by an overcurrent or undervoltage. The value must be set higher than the value of the parameter Operate delay. The difference shall be greater than 0.5 s. In the default setting, a difference of 1 s is used.

Parameter: Vph-ph< threshold

- Default setting (_:105) Vph-ph< threshold = 60.000 V

With the parameter Vph-ph< threshold, you can set the threshold at which the output signal *Voltage release* is activated when the minimum phase-to-phase voltage falls below this threshold.

Parameter: V2> threshold

- Default setting (_:106) V2> threshold = 4.600 V

With the parameter V2> threshold, you can set the threshold at which the output signal *Voltage release* is issued when V2 exceeds the threshold.

6.4.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Vseal-in+Vrel#				
_:1	Vseal-in+Vrel#:Mode		• off • on • test	off
_:2	Vseal-in+Vrel#:Operate & flt.rec. blocked		• no • yes	no
_:3	Vseal-in+Vrel#:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 100 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.350 A
		5 A @ 50 Irated	0.150 A to 175.000 A	6.750 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.350 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.750 A
_:6	Vseal-in+Vrel#:Operate delay		0.00 s to 60.00 s	3.00 s
_:10	Vseal-in+Vrel#:Blk. by meas. volt. failure		• no • yes	yes
_:101	Vseal-in+Vrel#:State of V-seal-in		• off • on	off
_:102	Vseal-in+Vrel#:V-seal-in threshold		0.300 V to 175.000 V	46.200 V
_:104	Vseal-in+Vrel#:Duration of V-seal-in time		0.10 s to 60.00 s	4.00 s
_:105	Vseal-in+Vrel#:Vph-ph< threshold		0.300 V to 175.000 V	60.000 V
_:106	Vseal-in+Vrel#:V2> threshold		0.300 V to 200.000 V	4.600 V

6.4.6.4 Information List

No.	Information	Data Class (Type)	Type
Vseal-in+Vrel#			
_:81	Vseal-in+Vrel#:>Block stage	SPS	I
_:500	Vseal-in+Vrel#:>Block V-seal-in	SPS	I
_:52	Vseal-in+Vrel#:Behavior	ENS	O
_:53	Vseal-in+Vrel#:Health	ENS	O
_:54	Vseal-in+Vrel#:Inactive	SPS	O
_:55	Vseal-in+Vrel#:Pickup	ACD	O
_:300	Vseal-in+Vrel#:Pickup I>+V-seal-in	SPS	O
_:301	Vseal-in+Vrel#:Voltage release	SPS	O
_:56	Vseal-in+Vrel#:Operate delay expired	ACT	O
_:57	Vseal-in+Vrel#:Operate	ACT	O

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6.5 Overcurrent Protection, Ground

6.5.1 Overview of Functions

The Overcurrent protection, ground function (ANSI 50N/51N):

- Detects short circuits in electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection

6.5.2 Structure of the Function

The **Overcurrent protection, ground** function is used in protection function groups. 2 kinds of functions are available for the 3-phase overcurrent protection:

- **Overcurrent protection, ground – advanced (50N/51N OC-gnd-A)**
- **Overcurrent protection, ground – basic (50N/51N OC gnd B)**

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 **Definite time-overcurrent protection** stages and with 1 **Inverse time-overcurrent protection** stage.

In the function type **Overcurrent protection, ground – advanced** the following stages can be operated simultaneously:

- Maximum of 3 stages **Definite time-overcurrent protection – advanced**
- 1 stage **Inverse time-overcurrent protection – advanced**
- 1 stage **User-defined characteristic curve overcurrent protection**

In the function type **Overcurrent protection, ground – basic** the following stages can be operated simultaneously:

- Maximum of 3 stages **Definite time-overcurrent protection – basic**
- 1 stage **Inverse time-overcurrent protection – basic**

The non-preconfigured stages are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The measured-value selection (only advanced stage) is general functionality and has a uniform effect on the stages (see Figure 6-32 and chapter 6.5.3.1 Description). This ensures that all stages of the function receive the same measured current value.

The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications.

- Pickup
- Operate

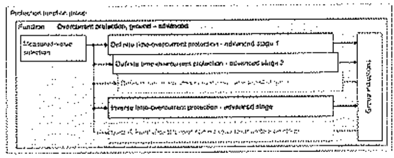

Figure 6-32 Structure/Embedding the Function Overcurrent Protection, Ground - Advanced

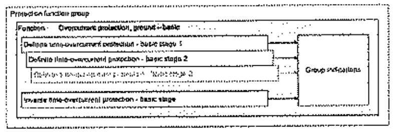

Figure 6-33 Structure/Embedding the Function Overcurrent Protection, Ground - Basic

If the following listed, device internal functions are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

If the device is equipped with an inrush-current detection function, the stages can be stabilized against tripping due to transformer-inrush currents (available in both function types).

6.5.3 General Functionality

6.5.3.1 Description

Measured-Value Selection

The function provides the option to select between the values *IN measured* or *3I0 calculated*.

Figure 6-34 Logic Diagram of Measured Value Selection

Both options are only available for the current transformer connection types *3-phase + IN* and *3-phase + IN-separate*. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

Table 6-2 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph – IN-separate	3I0 calculated	4 * Protection	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	0.15 A to 175.00 A	0.030 A to 35.000 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.5.3.2 Application and Setting Notes

Parameter: Measured value

- Recommended setting value *Measured value* = *IN Measured*

This parameter is not available in the basic function.

Parameter Value	Description
IN Measured	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
3I0 Calculated	The function operates with the calculated zero sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

6.5.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:9	General:Measured value		• 3I0 calculated • IN measured	IN measured

6.5.4 Stage with Definite-Time Characteristic Curve

6.5.4.1 Description

Logic of the Basic Stage

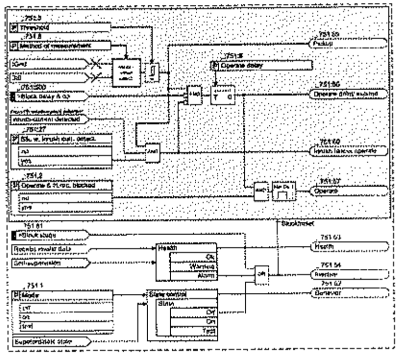

Figure 6-35 Logic Diagram of the Definite Time-Overcurrent Protection (Ground) – Basic

Logic of the Advanced Stage

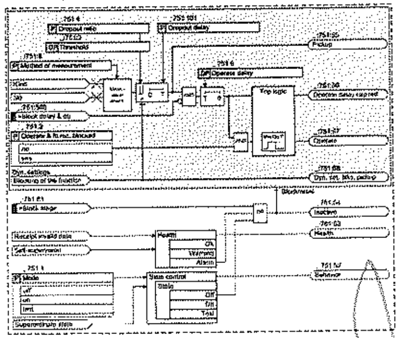

Figure 6-36 Logic Diagram of the Definite Time-Overcurrent Protection (Ground) – Advanced

Method of Measurement (Basic and Advanced Stage)

You use the *Method of measurement* parameter to define whether the stage uses the *fundamental comp.* or the calculated *RMS value*.

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

Dropout Delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage from an external or internal source
- Via the functionality of the dynamic settings (see chapter Influence of other functions via dynamic settings and section 6.5.8.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.5.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.5.8.1 Description.

6.5.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:751:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Threshold, Operate delay

- Default setting (_:751:3) Threshold = 1.20 A (for the first stage)
- Default setting (_:751:6) Operate delay = 0.300 s (for the first stage)

Set the Threshold and Operate delay parameters for the specific application.

The following details apply to a 2-stage characteristic curve (1st stage = definite time-overcurrent protection stage and 2nd stage = high-current stage).

1st stage (overcurrent stage):

The setting depends on the minimal occurring ground-fault current. This must be determined.

The Operate delay to be set is derived from the time-grading schedule that has been prepared for the system.

2nd stage (high-current stage):

This tripping stage can also be used for current grading. This applies in the case of very long lines with low source impedance or ahead of high reactances (for example, transformers, shunt reactors). Set the Threshold parameter to ensure that the stage does not pick up in case of a short circuit at the end of the line.

Set the Operate delay parameter to 0 or to a low value.

Siemens recommends that the threshold values be determined with a system analysis. The following example illustrates the principle of grading with a current threshold on a long line.

EXAMPLE

High-current stage: 110-kV overhead line, 150 mm² cross-section

s (length) = 60 km

Z_1/s = 0.46 Ω/km

Ratio of zero-sequence impedance and positive-sequence impedance of the line: $Z_0/Z_1 = 4$

Short-circuit power at the beginning of the line:

S_k'' = 2.5 GVA

Ratio of zero-sequence impedance and positive-sequence impedance of the source impedance at the beginning of the line: $Z_0/Z_1 = 2$

Current transformer = 600 A/5 A

Resulting in the following values for the line impedance Z_L and the source impedance Z_S:

$Z_L = 0.46\ \Omega/\text{km} \cdot 60\ \text{km} = 27.6\ \Omega$

$$Z_S = \frac{110\ \text{kV}^2}{2500\ \text{MVA}} = 4.84\ \Omega$$

The 1-pole short-circuit current at the end of the line is $I_{sc,end}$:

$$I_{sc,end} = \frac{1.1 \cdot V_N \cdot 3}{\sqrt{3} \cdot \left|Z_S \cdot \left(2 + \frac{Z_{0S}}{Z_{1S}}\right) + Z_L \cdot \left(2 + \frac{Z_{0L}}{Z_{1L}}\right)\right|} = \frac{1.1 \cdot 110\ \text{kV} \cdot 3}{\sqrt{3} \cdot (4.84\ \Omega \cdot (2+2) + 27.6\ \Omega \cdot (2+4))} = 1133\ \text{A}$$

The settings in primary and secondary values result in the following setting values which include a safety margin of 10 %:

Threshold value 2nd stage (primary) = 1.1 · 1133 A = 1246.3 A

Threshold value 2nd stage (secondary) $= 1.1 \cdot \frac{1133\ \text{A}}{600\ \text{A}} \cdot 5\ \text{A} = 10.39\ \text{A}$

In case of short-circuit currents exceeding 1246 A (primary) or 10.39 A (secondary) there is a short-circuit on the line to be protected. The overcurrent protection can cut off this short circuit immediately.

Note: The amounts in the calculation example are accurate enough for overhead lines. If the source impedance, line impedance and zero-sequence impedance have very different angles, you have use complex numbers to calculate the Threshold.

Parameter: Dropout delay

- Recommended setting value (_:751:101) Dropout delay = 0

This parameter is not visible in the basic stage.

Siemens recommends to use the default setting 0 since the dropout of a protection stage must be done as fast as possible.

You can use the Dropout delay parameter ≠ 0 to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

Parameter: Dropout ratio

- Recommended setting value (_:751:4) Dropout ratio = 0.95

This parameter is not visible in the basic stage.

The recommended set value of 0.95 is appropriate for most applications.

To achieve high-precision measurements, the setting value of the parameter Dropout ratio can be increased, for example, to 0.98. If you expect highly fluctuating measurands at the response threshold, you can reduce the setting value of the parameter Dropout ratio. This avoids chattering of the tripping stage.

6.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:751:1	Definite-T 1:Mode		• off • on • test	off
_:751:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:751:26	Definite-T 1:Dynamic settings		• no • yes	no
_:751:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:751:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:751:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:751:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:751:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:751:28	Definite-T 1:Effect. by AR off/n.rdy		• no • yes	no
_:751:35	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 1				
_:751:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:751:36	Definite-T 1:Stage blocked		• no • yes	no
_:751:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:751:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:751:37	Definite-T 1:Stage blocked		• no • yes	no
_:751:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:751:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:751:38	Definite-T 1:Stage blocked		• no • yes	no
_:751:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:751:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:751:39	Definite-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:751:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: Cold load PU				
_:751:33	Definite-T 1:Effect. b. cold load pickup		• no • yes	no
_:751:40	Definite-T 1:Stage blocked		• no • yes	no
_:751:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:751:34	Definite-T 1:Effected by binary input		• no • yes	no
_:751:41	Definite-T 1:Stage blocked		• no • yes	no
_:751:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:751:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.5.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:751:81	Definite-T 1:>Block stage	SPS	I
_:751:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:751:500	Definite-T 1:>Block delay & op.	SPS	I
_:751:54	Definite-T 1:Inactive	SPS	O
_:751:52	Definite-T 1:Behavior	ENS	O
_:751:53	Definite-T 1:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:751:60	Definite-T 1:Inrush blocks operate	ACT	O
_:751:55	Definite-T 1:Pickup	ACD	O
_:751:56	Definite-T 1:Operate delay expired	ACT	O
_:751:57	Definite-T 1:Operate	ACT	O

6.5.5 Stage with Inverse-Time Characteristic Curve

6.5.5.1 Description

Logic of the Basic Stage

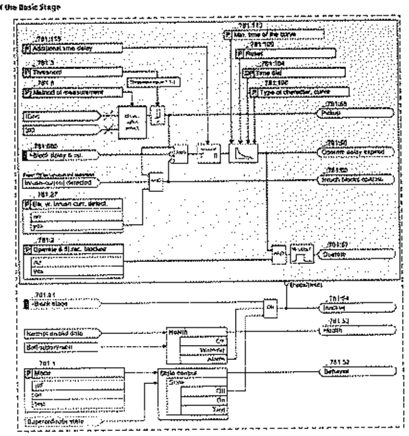

Figure 6-37 Logic Diagram of the Inverse-Time Overcurrent Protection (Ground) - Basic

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Logic of the Advanced Stage

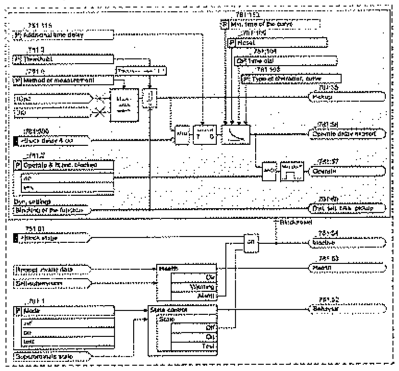

Figure 6-38 Logic Diagram of the Inverse Time-Overcurrent Protection (Ground) – Advanced

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

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

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

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

Minimum Time of the Curve (Advanced Stage)

With the parameter Min. time of the curve, you define the minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.

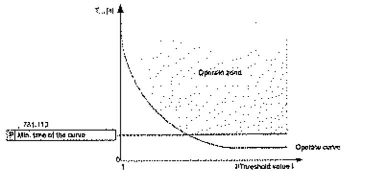

Figure 6-39 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time

Method of Measurement (Basic and Advanced Stage)

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

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

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Via the binary input signal >Block stage from an external or internal source
- Via the functionality of the dynamic settings (see subtitle Influence of other functions via dynamic settings and chapter 6.5.8.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device internal inrush-current detection function is described in chapter 6.5.7.1 Description .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.5.8.1 Description .

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent protection stages:

- Automatic reclosing
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.5.8.1 Description .

6.5.5.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:781:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than $0.1 I_{rated,sec}$

Parameter: Type of character. curve

- Default setting (_:781:108) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application. For more information about the parameter Type of character. curve, refer to chapter 12.7.2 Stage with Inverse-Time Characteristic Curve.

Parameter: Min. time of the curve

- Default setting (_:781:113) Min. time of the curve = 0.00 s

This parameter is only available in the advanced stage.

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Recommended setting value (_:781:115) Additional time delay = 0.00 s

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

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s

Parameter: Threshold

- Default setting (_:781:3) Threshold = 1.20 A

The setting depends on the minimal occurring ground-fault current. This must be determined.

Parameter: Time dial

- Default setting (_:781:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.

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

Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1.

Parameter: Reset

- Default setting (_:781:109) Reset = disk emulation

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

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

6.5.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:781:1	Inverse-T 1:Mode		• off • on • test	off
_:781:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:781:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:781:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:781:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:781:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:108	Inverse-T 1:Type of character. curve			
_:781:113	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:781:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:781:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:781:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:781:28	Inverse-T 1:Effect. by AR off/n.rdy		• no • yes	no
_:781:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:781:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:781:36	Inverse-T 1:Stage blocked		• no • yes	no
_:781:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:781:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:781:37	Inverse-T 1:Stage blocked		• no • yes	no
_:781:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:781:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:781:38	Inverse-T 1:Stage blocked		• no • yes	no
_:781:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:781:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:781:39	Inverse-T 1:Stage blocked		• no • yes	no
_:781:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:781:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:781:40	Inverse-T 1:Stage blocked		• no • yes	no
_:781:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:781:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:781:41	Inverse-T 1:Stage blocked		• no • yes	no
_:781:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:781:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

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6.5.5.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:781:81	Inverse-T 1:>Block stage	SPS	I
_:781:500	Inverse-T 1:>Block delay & op.	SPS	I
_:781:54	Inverse-T 1:Inactive	SPS	O
_:781:52	Inverse-T 1:Behavior	ENS	O
_:781:53	Inverse-T 1:Health	ENS	O
_:781:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:781:59	Inverse-T 1:Disk emulation running	SPS	O
_:781:55	Inverse-T 1:Pickup	ACD	O
_:781:56	Inverse-T 1:Operate delay expired	ACT	O
_:781:57	Inverse-T 1:Operate	ACT	O

6.5.6 Stage with User-Defined Characteristic Curve

6.5.6.1 Description

This stage is only available in the advanced function type.

This stage is structured the same way as the Inverse time-overcurrent protection – advanced stage (see chapter 6.5.5.1 Description). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

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

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

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

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

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

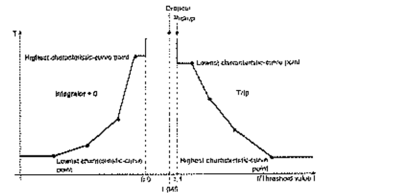

Figure 6-40 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

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

6.5.6.2 Application and Setting Notes

This stage is structured the same way as the Inverse time-overcurrent protection – advanced stage. The only difference is that the user can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves. For guidance on the other parameters of the stage, see chapter 6.5.5.2 Application and Setting Notes.

Parameter: Current/time value pairs (from the operate curve)

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

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

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

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

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

Use the Time dial parameter to displace the characteristic curve in the time direction.

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

Parameter: Reset

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

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

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/time value pairs (of the dropout characteristic curve)

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

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

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

NOTE

The value pairs must be entered in continuous order.

6.5.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation

Addr.	Parameter	C	Setting Options	Default Setting
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Effected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: bin.input				
_:34	User curve #:Effected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.5.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.5.7 Blocking of the Tripping by Device-Internal Inrush-Current Detection

6.5.7.1 Description

With the Blk. w. inrush curr. detect. parameter, you can define whether tripping of the stage should be blocked when a threshold value is exceeded due to an inrush current. In case of a blocking, the stage picks up. The start of the tripping delay and the trip signal are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. After that time, the stage operates. The following figure only shows the part of the stage (exemplified by definite time-overcurrent protection stage 1) that illustrates the influence of the inrush-current detection. Only if the central function Inrush-current detection (see section 7.7.20 Inrush-Current Detection) is in effect can the blocking be set.

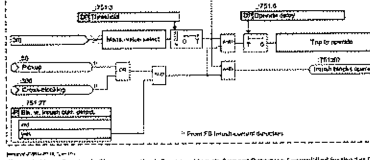

Figure 6-41 Part-Logic Diagram on the Influence of Inrush-Current Detection Exemplified by the 1st Definite Time Overcurrent Protection Stage

6.5.7.2 Application and Setting Notes

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:751:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This, for example, applies to the high-current stage that is set such according to the short-circuit voltage V_k of the transformer that it only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.

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Parameter Value	Description
yes	When the transformer inrush-current detection detects an inrush current that would lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

6.5.8 Influence of Other Functions via Dynamic Settings

6.5.8.1 Description

The Threshold and Operate delay settings used for tripping are so-called dynamic settings. Depending on other functions, the settings of these parameters can be changed dynamically. Depending on other functions, the stage can also be blocked dynamically. This functionality is only available in function type Advanced.

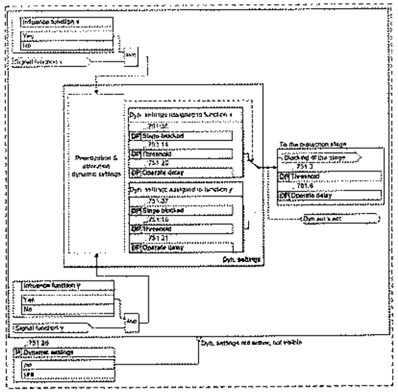

Figure 6-42 Principle of the Dynamic Settings in the Example of 1st Definite Time-Overcurrent Protection Stage

If available in the device, the following functionalities can affect the overcurrent-protection stages:

Functionalities	Priority
Automatic reclosing (AREC)	Priority 1
Cold-load pickup detection	Priority 2
Binary input signal	Priority 3

These functionalities generate signals that change the settings of the dynamic settings of the overcurrent-protection stage or block it, if required. In the latter case, the settings for the Threshold and the Operate delay are of no relevance. Within the overcurrent-protection stage, each of these signals is provided with a configuration parameter Influence of function ... and its own dynamic settings (Operate delay and Threshold). The configuration settings are used to set whether the signal shall be active or not, this means whether the dynamic settings shall be activated or not. If one of these signals (for example, signal function x) becomes active and is to take effect, these parameter settings become dynamic, that is, instantly active. This means that the setting assigned to the signal replaces the standard setting. If the signal becomes inactive, the standard settings apply again. The activation of the dynamic settings is reported.

When several signals are active in parallel, the priority specified above shall apply. This means that a signal with priority 2 precedes that of priority 3. The settings assigned to signal 2 become active.

The functionality of the dynamic settings can be disabled. In this case, the settings assigned to the signals are not visible and are without effect.

Link to the Device-Internal Function *Automatic Reclosing (Advanced Stage)*

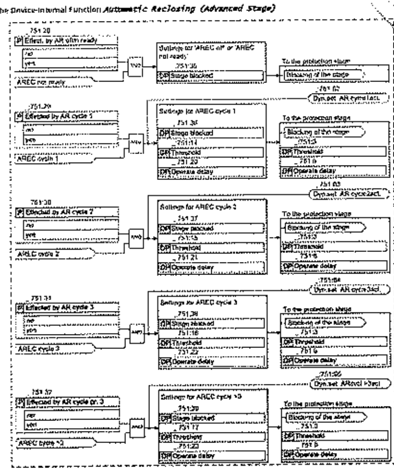

Figure 6-43 Influence of the AREC Signals on the Overcurrent-Protection Stage

Several AREC signals can affect the setting for the Threshold and the Operate delay of the protection stage and its blocking.

- AREC is ready for reclosing 1 (= Automatic reclosing cycle 1)
- AREC is ready for reclosing 2 (= Automatic reclosing cycle 2)
- AREC is ready for reclosing 3 (= Automatic reclosing cycle 3)
- AREC is ready for reclosing 4 (= Automatic reclosing cycle >3)

The following signal can only block the protection stage:

- AREC is not ready or switched off (= Automatic reclosing off / not ready)

This means that if the AREC is ready and the protection stage is in the idle state, the settings for AREC cycle 1 are active and not the standard settings. The standard settings are active in the case of AREC off/not ready.

The influence can be activated for each signal individually. You also have to set the Threshold and Operate delay or Stage blocked parameters, which take effect when the signal is active.

The way AREC signals are generated is described in chapter 6.4.1.1 Overview of Functions.

Link to the Device-Internal Function *Cold-Load Pickup Detection (Advanced Stage)*

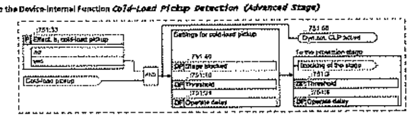

Figure 6-44 Influence of the Cold-Load Pickup Detection on the Overcurrent-Protection Stage

You have the option of changing the settings for the Threshold and the Operate delay of the protection stage for a cold-load pickup. You can also block the stage. To do so, you must activate the influence of the cold-load pickup. You also have to set the Threshold and Operate delay or assign settings to Stage blocked, which take effect when the signal is active.

The way signals are generated Cold-load pickup is described in chapter 5.8.8 Cold-Load Pickup Detection (Optional).

Link to an External *Function via a Binary Input Signal (Advanced Stage)*

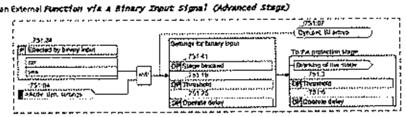

Figure 6-45 Influence of the Binary Input on the Overcurrent-Protection Stage

You can use the binary input signal >Activ. dyn. settings to change the settings for the Threshold and the Operate delay of the protection stage. You can also block the stage. To do so, you must activate the influence of the binary input. You also have to set the Threshold and Operate delay or assign settings to Stage blocked, which take effect when the signal is active.

6.5.8.2 Application and Setting Notes (Advanced Stage)

Binary Input Signal: Dynamic settings

- Default setting (_:751:26) Dynamic settings = no

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (automatic reclosing function or cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or time delay, blocking of the stage), the setting must be changed to yes. This makes the configuration parameters Influence of function... as well as the dynamic settings Threshold, Operate delay and Stage blocked of the stage visible and enables the settings to be set for the specific influence.

Influence of AREC

The example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing describes the influence exerted by AREC.

The setting of the overcurrent level (1st level) results from the time-grading schedule. It is to be used as fast stage before an automatic reclosing. Because fast disconnection of the short-circuit current takes priority over the selectivity prior to reclosing, the Operate delay parameter can be set to 0 or to a very low value. To achieve the selectivity, the final disconnection must be done with the grading time.

AREC is set to 2 reclosings. A secondary Threshold of 1.5 A and a Operate delay of 600 ms are assumed (according to the time grading schedule) for the overcurrent-protection stage. The standard settings of the stage are set to these values.

To realize the application, the configuration settings Effected by AR cycle 1 and Effected by AR cycle 2 are changed in the example to yes (= influenced). This activates the AR cycle 1 and AR cycle 2 input signals within the stage. When they become active, they switch to the assigned dynamic settings.

The two dynamic settings Operate delay assigned to these input signals (sources of influence) are set to the time delay 0 (instantaneous tripping). The two dynamic settings Threshold assigned to these input signals are set to the normal threshold value of 1.5 A.

If the threshold value (1.5 A) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of 600 ms according to the time-grading schedule.

Influence of External Devices

The influence of an external device can also be configured. The above is an example of how the overcurrent-protection stage (1st stage) can be used as a fast stage before automatic reclosing, in which case the AREC function is performed by an external device.

To realize the application, the configuration setting Effected by binary input must be changed to yes (= influenced). This activates the >Activ. dyn. settings input signal within the stage. When the input signal becomes active, it switches to the assigned dynamic settings. The external device must provide the Cycle 1 and Cycle 2 signals or, alternatively, an AREC ready signal. The signals must be connected with the binary input signal >Activ. dyn. settings.

The dynamic setting Operate delay, which is assigned to the input signal (source of influence) >Activ. dyn. settings, is set to the time delay 0 (instantaneous tripping). The dynamic setting Threshold assigned to this input signal is set to the normal threshold value of 1.5 A.

If the threshold value (1.5 A) is exceeded before AREC 1 and AREC 2, the overcurrent-protection stage trips instantaneously. If the fault still exists after AREC 2 (unsuccessful AREC), the stage trips with the time delay of 600 ms according to the time grading schedule.

6.6 Directional Overcurrent Protection, Phases

6.6.1 Overview of Functions

The Directional time-overcurrent protection, phases (ANSI 67):

- Detects short circuits at electrical equipment
- Can be used as backup overcurrent protection in addition to the main protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.6.2 Structure of the Function

The Directional time-overcurrent protection, phases function is used in protection function groups. 2 function types are offered:

- **Directional time-overcurrent protection, phases - advanced (67 Dir.OC-3ph-A)**
- **Directional time-overcurrent protection, phases - basic (67 Dir.OC-3ph-B)**

The Basic function type is provided for standard applications. The Advanced function type offers more functionality and is provided for more complex applications.

Both function types are preconfigured by the manufacturer with 2 directional, **definite time-overcurrent** protection stages and with 1 **directional inverse time-overcurrent protection stage.**

In the advanced function type **Directional time-overcurrent protection, phases – advanced** the following stages can be operated simultaneously:

- **Maximum of 4 stages Definite time-overcurrent protection – advanced**
- **1 stage Inverse time-overcurrent protection – advanced**
- **1 stage User-defined overcurrent protection characteristic curve**

In the Basic function type **Directional time-overcurrent protection, phases – basic** the following stages can be operated simultaneously:

- **Maximum of 4 stages Definite time-overcurrent protection – basic**
- **1 stage Inverse time-overcurrent protection – basic**

Stages that are not preconfigured are shown in gray in the following figures. Apart from the tripping delay characteristic, the stages are identical in structure.

The direction determination occurs on function level and has the same effects on all stages (see following figure and chapter 6.6.7.1 Description). In this way, it is ensured that all stages of a function receive the same direction result. Every stage can be set to the forward or reverse direction.

The group-indication output logic generates the following group indications of the protection function by the logical OR of the stage-selective indications:

- Pickup
- Operate

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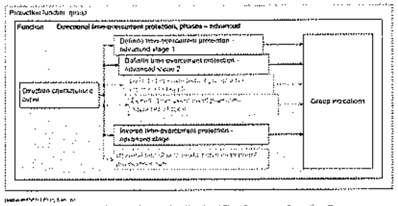

Figure 6-46 Structure/Embedding the Function Directional Time-Overcurrent Protection, Phases – Advanced

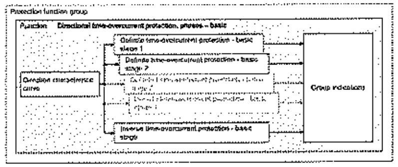

Figure 6-47 Structure/Embedding the Function Directional Time Overcurrent Protection, Phases - Basic

If the device-internal functions listed in the following are present in the device, these functions can influence the pickup values and tripping delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

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

6.6.3 Stage Control

6.6.3.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.

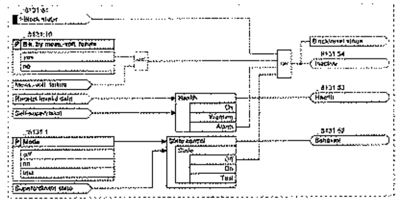

Figure 6-48 Stage Control Logic Diagram

Blocking of the Stage with Measuring-Voltage Failure (Basic and Advanced Stage)

The stage can be blocked if a measuring voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From inside on pickup of the Measuring-voltage failure detection function (see chapter 9.3.2.1 Overview of Functions)
- From an external source via the binary input signal >Open of the function block Volt.-transf. c.b., which links in the tripping of the voltage transformer circuit breaker

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

6.6.3.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:8131:10) Blk. by meas.-volt. failure = yes

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

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

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on
- The binary input signal >Open of the function block VT CB is connected to the voltage-transformer circuit breaker (see chapter 9.3.4.1 Overview of Functions).

Parameter Value	Description
yes	The directional overcurrent protection stage is blocked. Siemens recommends that you retain the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent protection stage is not blocked.

6.6.4 Stage with Definite-Time Characteristic Curve

6.6.4.1 Description

Logic of the Basic Stage

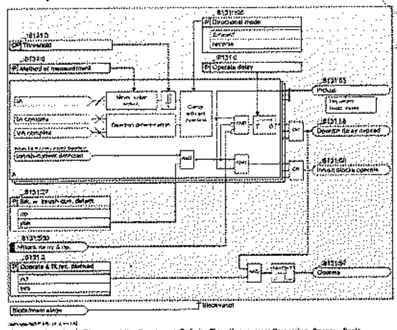

Figure 6-49 Logic Diagram of the Directional, Definite Time-Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage

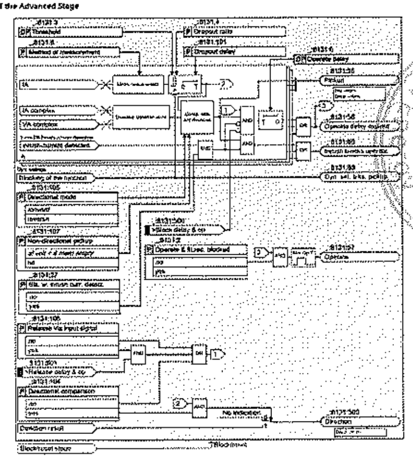

Figure 6-50 Logic Diagram of the Directional, Definite Time Overcurrent Protection, Phases - Advanced

Directional mode (Basic and Advanced Stage)

You use the Directional mode parameter to define whether the stage works in a forward or reverse direction.

Direction determination itself works across stages (see section 6.6.7.1 Description).

Non-Directional Pickup, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter 6.6.7.1 Description). If no voltage measure-

ments which can be used to determine the direction are available in the voltage memory, the basic stage generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the Non-directional pickup parameter. With the at volt.< & mem.empty setting, the function picks up in such a situation without direction determination. With the no setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the Directional comparison parameter. With the yes setting, the function uses the threshold value violation to determine the direction (forward or reverse) and reports the indication Direction. The direction indicated is independent of the directional mode set for the stage.

The Release via input signal setting and the >Release delay & op. input signal are available with directional comparison protection. If the Release via input signal parameter is set to yes, the start of the time delay, and therefore the tripping of the stage, are only enabled if the >Release delay & op. input signal is active.

Method of measurement (Basic and Advanced Stage)

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

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

Dropout delay (Advanced Stage)

If the value falls below the dropout threshold, the pickup dropout can be delayed. The pickup is maintained for the specified time. The tripping delay continues to run. If the time delay expires while the pickup is still maintained, the stage operates.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal >Block stage (see chapter 6.6.3.1 Description)
- Measuring-voltage failure (see chapter 6.6.3.1 Description)
- Via the dynamic settings function (only provided in the Advanced function type, see chapter Influence of other functions via dynamic settings and chapter 6.3.4.1 Description)

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and the fault logging and recording takes place.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.2.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.3.8.1 Description.

6.6.4.2 Application and Setting Notes

Parameter: Directional mode

- Default setting (_:8131:105) Directional mode = forward

You use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value (_:8131:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the Threshold value of the stage to less than 0.1 $I_{rated,sec}$

Parameter: Directional comparison, Release via input signal

- Default setting (_:8131:104) Directional comparison = no
- Default setting (_:8131:106) Release via input signal = no

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the Direction and >Release delay & op. signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.

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Parameter Value	Description
yes	If the Directional comparison parameter is set to yes, the Release via input signal parameter, the Direction output signal and the >Release delay & op. input signal become visible. If the Release via input signal parameter is set to yes, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the >Release delay & op. input signal is active. The >Release delay & op. input signal must be connected to the 'release' information from the opposite end (forward information from the Direction output signal); see also the application example in chapter 6.6.10 Application Notes for Directional Comparison Protection.

Parameter: Non-directional pickup

- Recommended setting value (_:8131:107) Non-directional pickup = at volt.< & mem.empty

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the circuit breaker (CB) trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: Threshold

- Default setting (_:8131:3) Threshold = 1.50 A (for the first stage)

The same considerations apply to setting the threshold value as for non-directional overcurrent protection, for further information, refer to section 6.2.4.2 Application and Setting Notes.

Parameter: Operate delay

- Default setting (_:8131:6) Operate delay = 0.300 s (for the 1st stage)

The Operate delay to be set is derived from the time-grading schedule that has been prepared for the system. Typical examples of grading times are provided in the chapters 6.6.9 Application Notes for Parallel Lines and 6.6.10 Application Notes for Directional Comparison Protection.

Parameter: Dropout ratio

- Recommended setting value (_:8131:4) Dropout ratio = 0.95

This parameter is not visible in the basic stage.
The recommended set value of 0.95 is appropriate for most applications.
For high-precision measurements, the setting value of the Dropout ratio parameter can be reduced, for example to 0.98. If you expect heavily fluctuating measurands at the response threshold, you can increase the setting value of the Dropout ratio parameter. This avoids chattering of the tripping stage.

Parameter: Dropout delay

- Recommended setting value (_:8131:101) Dropout delay = 0 s

This parameter is not visible in the basic stage.
Siemens recommends using this setting value, since the dropout of a protection stage must be performed as fast as possible.

You can use the Dropout delay parameter ≠ 0 s to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical Data) and set the result.

6.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
Definite 1				
_:8131:1	Definite-T 1:Mode		• off • on • test	off
_:8131:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8131:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:8131:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8131:107	Definite-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8131:104	Definite-T 1:Directional comparison		• no • yes	no
_:8131:106	Definite-T 1:Release via input signal		• no • yes	no
_:8131:10	Definite-T 1:Blk. by meas. volt. failure		• no • yes	yes
_:8131:26	Definite-T 1:Dynamic settings		• no • yes	no
_:8131:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8131:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:8131:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:8131:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:8131:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8131:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8131:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8131:36	Definite-T 1:Stage blocked		• no • yes	no
_:8131:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:8131:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:8131:37	Definite-T 1:Stage blocked		• no • yes	no
_:8131:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:8131:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no
_:8131:38	Definite-T 1:Stage blocked		• no • yes	no
_:8131:16	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:22	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR cycle>3				
_:8131:32	Definite-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8131:39	Definite-T 1:Stage blocked		• no • yes	no
_:8131:17	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:23	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: Cold load PU				
_:8131:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8131:40	Definite-T 1:Stage blocked		• no • yes	no
_:8131:18	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:24	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: bin.input				
_:8131:34	Definite-T 1:Effected by binary input		• no • yes	no
_:8131:41	Definite-T 1:Stage blocked		• no • yes	no
_:8131:19	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8131:25	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.6.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:301	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:8131:81	Definite-T 1:>Block stage	SPS	I
_:8131:501	Definite-T 1:>Release delay & op	SPS	I
_:8131:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:8131:500	Definite-T 1:>Block delay & op.	SPS	I
_:8131:54	Definite-T 1:Inactive	SPS	O
_:8131:52	Definite-T 1:Behavior	ENS	O
_:8131:53	Definite-T 1:Health	ENS	O
_:8131:60	Definite-T 1:Inrush blocks operate	ACT	O
_:8131:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8131:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8131:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O

No.	Information	Data Class (Type)	Type
_:8131:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8131:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:8131:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:8131:68	Definite-T 1:Dyn. set. blks. pickup	SPS	O
_:8131:55	Definite-T 1:Pickup	ACD	O
_:8131:300	Definite-T 1:Direction	ACD	O
_:8131:56	Definite-T 1:Operate delay expired	ACT	O
_:8131:57	Definite-T 1:Operate	ACT	O

6.6.5 Stage with Inverse-Time Characteristic Curve

6.6.5.1 Description

Logic of the Basic Stage

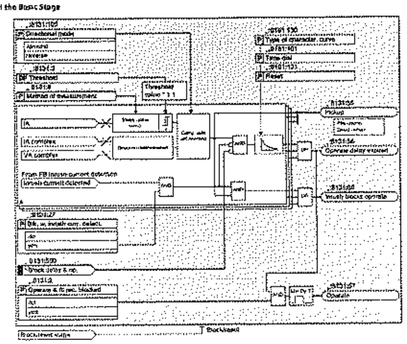

Figure 6-51 Logic Diagram of the Directional, Inverse Time Overcurrent Protection, Phases - Basic

Logic of the Advanced Stage

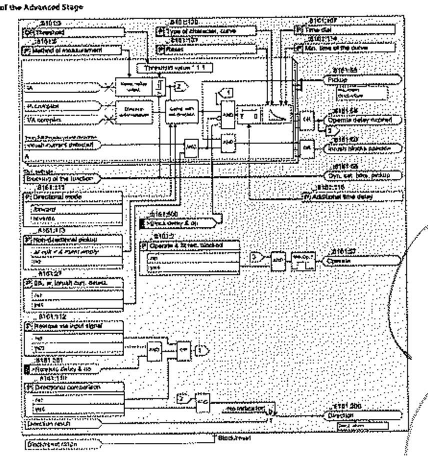

Figure 6-52 Logic Diagram of the Directional, Inverse Time-Overcurrent Protection, Phases - Advanced

Directional mode (Basic and Advanced Stage)

You use the Directional mode parameter to define whether the stage works in a forward or reverse direction.
The direction determination works across stages (see chapter 6.6.2.1 Description).

Non-directional pickup, Voltage Memory (Basic and Advanced Stage)

If a 3-phase close-up fault occurs, all 3 phase-to-ground voltages drop to almost 0. If this happens, direction determination can fall back on a voltage memory (see chapter 6.6.2.1 Description). If no voltage measurements which can be used to determine the direction are available in the voltage memory, the basic stage

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generally picks up without direction determination, that is non-directionally. For the advanced stage, the response can be defined via the Non-directional pickup parameter. With the at volt.< & mem.empty setting, the function picks up in such a situation without direction determination. With the no setting, the function does not pick up.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the Directional comparison parameter. With the yes setting, the function uses the threshold value violation to determine the direction (forward or reverse) and reports the indication Direction. The direction indicated is independent of the directional mode set for the stage.

The Release via input signal setting and the >Release delay & op. input signal are available with directional comparison protection. If the Release via input signal parameter is set to yes, the start of the time delay, and therefore the tripping of the stage, are only enabled if the >Release delay & op. input signal is active.

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve according to IEC and ANSI (Basic and Advanced Stage)

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

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

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

Minimum Time of the Curve (Advanced Stage)

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.

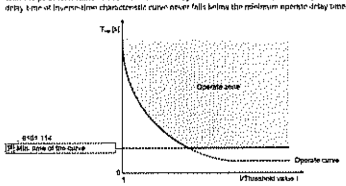

Figure 6-53 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal >Block stage (see chapter 6.6.3.1 Description)
- Measuring-voltage failure (see chapter 6.6.3.1 Description)
- Via the functionality of the dynamic settings (only in the advanced function type, see subtitle Influence of other functions via dynamic settings and chapter 6.3.3.1 Description).

Blocking of the Time Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate signal. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Delay and the Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.3.7.1 Description.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can influence the overcurrent-protection stages:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.3.6.1 Description.

6.6.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting (_:8161:111) Directional mode = forward

You use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in a forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in a reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value (_:8161:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.

Parameter Value	Description
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 I_{rated}.

Parameter: Directional comparison, Release via input signal

- Default setting (_:8161:110) Directional comparison = no
- Default setting (_:8161:112) Release via input signal = no

These 2 parameters are not visible in the basic stage.

You use these parameters to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the Direction and >Release delay & op. signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the Directional comparison parameter is set to yes, the Release via input signal parameter, the Direction output signal, and the >Release delay & op. input signal become available. If the Release via input signal parameter is set to yes, the start of the time delay, and therefore also the operate signal of the stage, are only enabled if the >Release delay & op. input signal is active. The >Release delay & op. input signal must be connected to the release information from the opposite end (forward information from the Direction output signal); see also the application example in chapter 6.6.10 Application Notes for Directional Comparison Protection.

Parameter: Non-directional pickup

- Recommended setting value (_:8161:113) Non-directional pickup = at volt.< & mem.empty

This parameter is not visible in the basic stage.

Parameter Value	Description
at volt.< & mem.empty	Select this setting if the stage is to pick up in a non-directional manner if the voltage memory is empty and determining of direction has to be performed at low voltages (3-phase close-up fault). An empty voltage memory may exist, for example, if there is a voltage transformer at the line end and the CB trips. Siemens recommends using the default setting.
no	Select this setting if determining of direction is required under all circumstances, that is, even in the event of pickup on a 3-phase close-up fault.

Parameter: Type of character. curve

- Default setting (_:8161:130) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application.

Parameter: Min. time of the curve

- Default setting (_:8161:114) Min. time of the curve = 0.00 s

This parameter is only available in the advanced stage.

With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

NOTE

If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting (_:8161:115) Additional time delay = 0.00 s

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

If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.

This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

Parameter: Threshold

- Default setting (_:8161:3) Threshold = 1.50 A

The same considerations apply to setting the threshold value as for non-directional overcurrent protection, therefore, refer to chapter 6.3.5.2 Application and Setting Notes for further information.

Parameter: Time dial

- Default setting (_:8161:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.

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

Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1 (default setting).

Parameter: Reset

- Default setting (_:8161:131) Reset = disk emulation

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

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

6.6.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	45 °
Inverse-T 1				
_:8161:1	Inverse-T 1:Mode		• off • on • test	off

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Addr.	Parameter	C	Setting Options	Default Setting
_:8161:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:8161:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:8161:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:8161:113	Inverse-T 1:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem.empty
_:8161:110	Inverse-T 1:Directional comparison		• no • yes	no
_:8161:112	Inverse-T 1:Release via input signal		• no • yes	no
_:8161:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:8161:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:8161:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8161:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:130	Inverse-T 1:Type of character. curve			
_:8161:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:8161:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:8161:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:8161:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s
Dyn.s: AR off/n.rdy				
_:8161:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:8161:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:8161:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:8161:36	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:8161:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:8161:37	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:8161:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:8161:38	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:8161:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:8161:39	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:8161:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:8161:40	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: Bin.input				
_:8161:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:8161:41	Inverse-T 1:Stage blocked		• no • yes	no
_:8161:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8161:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.6.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction	SPS	I
_:2311:301	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:8161:81	Inverse-T 1:>Block stage	SPS	I
_:8161:501	Inverse-T 1:>Release delay & op.	SPS	I
_:8161:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:8161:500	Inverse-T 1:>Block delay & op.	SPS	I
_:8161:54	Inverse-T 1:Inactive	SPS	O
_:8161:52	Inverse-T 1:Behavior	ENS	O
_:8161:53	Inverse-T 1:Health	ENS	O
_:8161:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:8161:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:8161:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:8161:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:8161:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:8161:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:8161:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:8161:68	Inverse-T 1:Dyn. set. blks. pickup	SPS	O
_:8161:59	Inverse-T 1:Disk emulation running	SPS	O
_:8161:55	Inverse-T 1:Pickup	ACD	O
_:8161:301	Inverse-T 1:Direction	ACD	O
_:8161:56	Inverse-T 1:Operate delay expired	ACT	O
_:8161:57	Inverse-T 1:Operate	ACT	O

6.6.6 Stage with User-Defined Characteristic Curve

6.6.6.1 Description

The structure of this stage is identical to that of the advanced stage with directional inverse-time characteristic curve (6.6.4.2 Description). The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

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

Pickup and Dropout Behavior with User-Defined Characteristic Curve

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

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

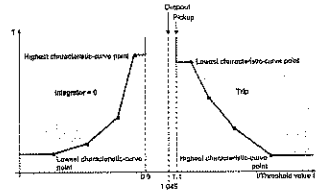

Figure 6-54 Pickup and Dropout Behavior When Using a Directional User-Defined Characteristic Curve

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

6.6.6.2 Application and Setting Notes

This stage is structured in the same way as the stage with a directional inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: Current/time value pairs (from the operate curve)

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

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

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

> **NOTE**
> The value pairs must be entered in continuous order.

Parameter: Time dial

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

Use the Time dial parameter to displace the characteristic curve in the time direction.

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

Parameter: Reset

- Default setting (_:115) Reset = disk emulation

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

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/time value pairs (of the dropout characteristic curve)

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

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

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

> **NOTE**
> The value pairs must be entered in continuous order.

6.6.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:110	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Non-directional pickup		• no • at volt.< & mem.empty	at volt.< & mem. empty
_:109	User curve #:Directional comparison		• no • yes	no
_:111	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:115	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Affected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: AR cycle 2				
_:30	User curve #:Affected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no
_:15	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:103	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 3				
_:31	User curve #:Affected by AR cycle 3		• no • yes	no
_:38	User curve #:Stage blocked		• no • yes	no
_:16	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:104	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR cycle>3				
_:32	User curve #:Effected by AR cycle gr. 3		• no • yes	no
_:39	User curve #:Stage blocked		• no • yes	no
_:17	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:105	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: Cold load PU				
_:33	User curve #:Effect. b. cold-load pickup		• no • yes	no
_:40	User curve #:Stage blocked		• no • yes	no
_:18	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:106	User curve #:Time dial		0.05 to 15.00	1.00

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.set: Bin.input				
_:34	User curve #:Affected by binary input		• no • yes	no
_:41	User curve #:Stage blocked		• no • yes	no
_:19	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:107	User curve #:Time dial		0.05 to 15.00	1.00

6.6.6.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:501	User curve #:>Release delay & op.	SPS	I
_:84	User curve #:>Activ. dyn. settings	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:62	User curve #:Dyn.set. AR cycle1act.	SPS	O
_:63	User curve #:Dyn.set. AR cycle2act.	SPS	O
_:64	User curve #:Dyn.set. AR cycle3act.	SPS	O
_:65	User curve #:Dyn.set. ARcycl.>3act	SPS	O
_:66	User curve #:Dyn.set. CLP active	SPS	O
_:67	User curve #:Dyn.set. BI active	SPS	O
_:68	User curve #:Dyn. set. blks. pickup	SPS	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:309	User curve #:Direction	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.6.7 Direction Determination

6.6.7.1 Description

General

Every phase has a separate direction-measuring element. If the threshold value in a phase is exceeded, the direction determination is started for this phase. If there are multiphase short circuits, all measuring elements involved perform direction determination independently. If one of the determined directions matches the set direction, the stage picks up (see descriptions of the stage logic).

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The direction is determined by calculating the phase angle between the short-circuit current and a reference voltage.

Measurands for Direction Determining

The directional measuring element uses the short-circuit current of the phase concerned and the cross-polarized phase-to-phase voltage (as the reference voltage) to determine the direction. This means that the direction can still be determined unambiguously and correctly, even if the short-circuit voltages collapse completely when a 1 or 2-phase fault occurs (close-up fault).

The phase-to-phase voltages are calculated when phase-to-ground voltages are connected.

The cross polarized voltage (reference voltage) is vertical in relation to the short circuit voltages for 1 phase-to-ground faults (Figure 6-55, left). For 2-phase short circuits, the position of the reference voltages changes up to 30°, depending on the extent to which the short-circuit voltages collapse (Figure 6-55, right).

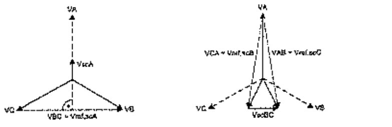

Figure 6-55 Cross-Polarized Voltages for Direction Determination

The following table shows how measurands are assigned for direction determination purposes in the event of different types of fault.

Table 6-3 Measurands for Direction Determining

Threshold-Value Exceeding	Measuring Element A		B		C		Ground	
	Current	Voltage	Current	Voltage	Current	Voltage	Current	Voltage
A	I_A	V_{BC}	-	-	-	-	-	-
B	-	-	I_B	V_{CA}	-	-	-	-
C	-	-	-	-	I_C	V_{AB}	-	-
Gnd	-	-	-	-	-	-	I_N	V_0
A, Gnd	-	V_{BC}	-	-	-	-	I_N	V_0
B, Gnd	-	-	I_B	V_{CA}	-	-	I_N	V_0
C, Gnd	-	-	-	-	I_C	V_{AB}	I_N	V_0
A, B	I_A	V_{BC}	I_B	V_{CA}	-	-	-	-
B, C	-	-	I_B	V_{CA}	I_C	V_{AB}	-	-
A, C	I_A	V_{BC}	-	-	I_C	V_{AB}	-	-
A, B, Gnd	I_A	V_{BC}	I_B	V_{CA}	-	-	I_N	V_0
B, C, Gnd	-	-	I_B	V_{CA}	I_C	V_{AB}	I_N	V_0
A, C, Gnd	I_A	V_{BC}	-	-	I_C	V_{AB}	I_N	V_0
A, B, C	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	-	-
A, B, C, Gnd	I_A	V_{BC}	I_B	V_{CA}	I_C	V_{AB}	-	V_0

Voltage Memory

Saved voltages are used if, when a 3-pole close-up fault occurs, the measuring voltages are not sufficient for reliable direction determination. Insofar as one as long as no sufficient measuring voltage is available after the storage time (2 s) has elapsed, the detected direction is retained. If the memory does not contain any voltages (when closing onto a short circuit, for example), the behavior of the stage is defined using the Non-directional pickup parameter.

Direction Determination

As mentioned in the General section, the direction is determined by calculating the phase angle between short circuit current and reference voltage. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (Rotation angle of ref. volt. parameter). This moves the vector of the rotated reference voltage close to the vector of the short-circuit current. Consequently, the result of direction determination is as reliable as possible. Figure 6-56 illustrates the relationship based on a 1-phase ground fault in phase A. The short-circuit current I_{scA} lags the short-circuit voltage by the short-circuit angle φ_{sc}. The reference voltage, in this case V_{BC} for measuring element A, is rotated positively (counterclockwise) by the setting value of the Rotation angle of ref. volt. parameter. In the scenario illustrated here, the rotation is +45°.

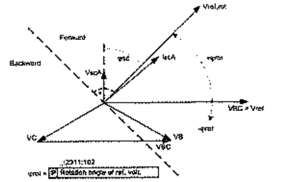

Figure 6-56 Rotation of the Reference Voltage, Phase-Measuring Element

The rotated reference voltage defines the forward and reverse range; see Figure 6-57. The forward range is calculated as ±88° around the rotated reference voltage $V_{ref,rot}$. If the short-circuit current vector is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the backward direction. In the intermediate range, the direction is undetermined.

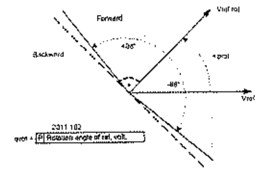

Figure 6-57 Forward Characteristic of the Directional Function, Phase-Measuring Element

Direction Determination for Test Purposes

If you activate the binary input signal >Test of direction, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as current and voltage are greater than approx. 7 % of their secondary rated values.

6.6.7.2 Application and Setting Notes

Parameter: Rotation angle of ref. volt.

- Default setting (_:2311:102) Rotation angle of ref. volt. = 45°

The directional characteristic, that is, the position of the forward and reverse ranges, is set with the Rotation angle of ref. volt. parameter. The short-circuit angle is typically to be found in a range from 30° to 60° inductive. Therefore, in most cases, the default setting of +45° can be retained to position the reference voltage, as it ensures a reliable directional result.

Some example settings for special applications appear in the following (Table 6-4). Please note that for phase-to-ground faults (PG faults), the reference voltage (fault-free voltage) is vertical in relation to the short-circuit voltage. This results in the following setting for the rotation angle:

Rotation angle of ref. volt. = 90 - φsh phase-measuring elements (PG faults)

Please also note that for phase-to-phase faults, the reference voltage is rotated between 0° (distant fault) and 30° (close-up fault) dependent upon the collapse of the faulted voltage (see Figure 6-56). You can take this into account with an average value of 15°:

Rotation angle of ref. volt. = 90 - φsh - 15° phase-measuring elements (PP faults)

Table 6-4 Example settings

Application	$\varphi_{sh\ typical}$	Setting Rotation angle of ref. volt.
Power-flow direction, Overhead line, SIPROTEC	60°	Range 30° to 0° for PP faults Selected: 15°

Application	$\varphi_{sh\ typical}$	Setting Rotation angle of ref. volt.
Power-flow direction, Underground line, SIPROTEC	30°	Range 60° to 30° for PP faults Selected: 45°
Power-flow direction, Transformer infeed, SIPROTEC, Assuming that underground lines are used.	30°	Range 60° to 30° for PP faults Selected: 45°

Input signal: >Test of direction

If you activate the binary input signal >Test of direction, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.6.8 Influence of Other Functions via Dynamic Settings

The influence of these functions via dynamic settings is described in chapter 6.3.8.1 *Description* and chapter 6.3.8.2 *Application and Setting Notes (Advanced Stage)*.

6.6.9 Application Notes for Parallel Lines and Cable Runs with Infeed at Both Ends

Parallel Lines or Transformers

In parallel lines or transformers with infeed at one end (see Figure 6-58), if there is no directional measuring element, a fault on feeder T1 will also trip the other feeder T2. In contrast, a directional measuring element in the devices on busbar B prevents the tripping of the circuit-breaker in the parallel feeder. Therefore, in Figure 6-58, directional time-overcurrent protection is used in the places marked with direction arrows. Please note that the forward direction of the protection device represents the direction towards the object to be protected. This does not have to be the same as the power direction of normal load flow.

Set time grading in opposition to the load flow with increasing time. As load can only flow in one direction, you can set the directional devices without time delay.

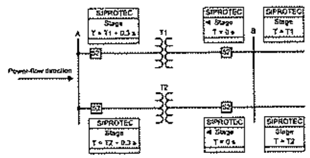

Figure 6-58 Parallel Line with Transformers

Legend for Figure 6-58

Stage ►:	Directional stage, forward direction set
Stage:	Non-directional stage
T:	Grading time

Cable Runs with Infeed at Both Ends

Cable runs with infeed at both ends and lines connected to form ring topologies also require that you supplement overcurrent protection with the directional criterion. Figure 6-59 shows a ring system implementation, with the 2 infeeds shown merging in the ring to form a single infeed. For the directional devices whose forward direction matches the power-flow direction, set time grading in opposition to the power flow with increasing time. As power flow from both ends is possible, grading has to be set at both ends.

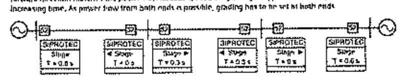

Figure 6-59 Cable Runs with Infeed at Both Ends

Legend for Figure 6-59

Stage ►:	Directional stage, forward direction set
Stage:	Non directional stage
T:	Grading time

6.6.10 Application Notes for Directional Comparison Protection

The direction determination of directional time overcurrent protection can be used to implement directional comparison protection for cable runs with infeed at both ends. Directional comparison protection is used for the selective isolation of a faulted line section (for example, subsections of closed rings). Sections are isolated in fast time, that is, they do not suffer the disadvantage of long grading times.

This technique requires that directional information can be exchanged between the individual protection stations. You can implement this information exchange using a communication channel (protection interface or IEC 61850 GOOSE) or with pilot wires for signal transmission via an auxiliary voltage loop.

Protection Principle

The protection principle is shown in Figure 6-60. 2 devices (one at the start of the line and the other at the end of the line) work together in each line section. The information fault in forward direction is transferred between them. A directional definite time-overcurrent protection level is in operation in both devices in the forward direction (1st level). However, this level is not enabled in the idle state. The level is only released when the information fault in forward direction is received from the opposite end. If the enabled level also defines the fault in the forward direction, the fault must be on this line section and the level trips immediately. As this protection principle works with an enable procedure (and not with a blocking procedure), there is no need to delay the level.

A second directional definite time-overcurrent protection stage with standard time grading works in parallel with the first stage as a selective backup stage. This ensures full selectivity of protection in the following situations:

- Infeed at one end or weak infeed at one end: In this case, no release signal is generated.
- Failure of the communication route: In this case, the release signal is not transmitted.

To provide selective protection in fast time for busbars between the line sections also, you can combine this protection principle with the principle of reverse interlocking. This principle is not discussed in further detail in this document.

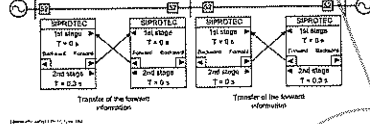

Figure 6-60 Selectivity through Directional Comparison Protection

Legend for Figure 6-60

Stage ►:	Stage is set in the forward direction, stage 1 is instantaneous, stage 2 is graded
►, ◄:	If a threshold value is exceeded, the stage indicates the direction (forward or reverse)

If you are using a communication channel, the protocol-transmission methods detect if the channel is interrupted. If you are using pilot wires, we recommend operation based on a closed-circuit connection. The device uses a function chart to check and indicate if the binary input is dead for an unexpectedly long period. In contrast with the blocking procedure, overfunction is not possible if communication is lost. Therefore, a loss of communication is not critical where this procedure is concerned, although it must be detected and indicated.

Directional comparison protection can also be implemented as a blocking procedure. This procedure works under all system switching states, i.e. also with infeed at one end (or weak infeed). However, to use it you must delay the stage (typically by 100 ms) so that the blocking signal is received in time under all circumstances. It is also essential that you monitor the communication channel to avoid overfunction in the event of a failure followed by a system incident.

Configuration of the Stage, Function Chart

To configure the stage, proceed as follows:

- The Directional mode parameter of both stages must be set to *forward*.
- The Directional comparison and Release via input signal parameters of the first stage must be set to yes. This is so that the first stage is only released if the >Release delay & op. input signal is active. Furthermore, the direction is indicated if a threshold value is exceeded.
- The first stage can be set without a time delay. The second stage has to be graded.

- The information forward from the Direction signal in the first stage must be transmitted to the opposite end. The routing is determined by the type of transmission
- A function chart has to be implemented at the receive end to link the received (forward information) and reverse signals dependent upon the type of transmission

6.7 Directional Overcurrent Protection, Ground

6.7.1 Overview of Functions

The Directional time-overcurrent protection, ground function (ANSI 67N):

- Detects short circuits to ground affecting electric equipment
- Ensures selective ground fault detection for parallel lines or transformers with infeed at one end
- Ensures selective ground fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

6.7.2 Structure of the Function

The Directional time-overcurrent protection, ground function can be used in protection function groups which provide zero-sequence current and zero-sequence voltage measurements. 2 function types are offered:

- **Directional time-overcurrent protection, ground – advanced** (67N Dir.OC-gnd-A)
- **Directional time-overcurrent protection, ground – basic** (67N Dir.OC-gnd-B)

The basic function type shall be used for standard applications. The advanced function type provides more functionalities and is intended for more sophisticated applications.

Both function types are preconfigured by the manufacturer with 2 **Definite time-overcurrent protection** stages and 1 **Inverse time-overcurrent protection stage**.

In the advanced function type **Directional time-overcurrent protection, ground – advanced**, the following stages can operate simultaneously:

- A maximum of 4 **Definite time-overcurrent protection – advanced stages**
- 1 **Inverse time-overcurrent protection – advanced stage**
- 1 **Logarithmic inverse time-overcurrent protection stage**
- 1 **Logarithmic inverse time with knee-point overcurrent protection stage**
- 1 **User-defined characteristic curve overcurrent protection stage**

In the basic function type **Directional time-overcurrent protection, ground – basic**, the following stages can operate simultaneously:

- A maximum of 4 **Definite time-overcurrent protection – basic stages**
- 1 **Inverse time-overcurrent protection – basic stage**

Referring to Figure 6-61 and Figure 6-62, the stages not preconfigured are shown in gray. Apart from the operate-delay characteristic curve, the stages are similar in structure.

The general functionality includes the direction determination and the measured-value selection (only advanced function). They take place on the functional level and have a uniform effect on the stages (see Figure 6-61 and chapter General Functionality. This ensures that all stages of the function receive the same measured current value and the same direction result. Each stage can be set to work in forward or reverse direction.

The group indication output logic generates the following group indications for the protection function by the logic OR from the stage-selective indications:

- Pickup
- Operate

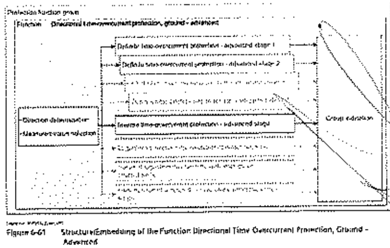

Figure 6-61 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Advanced

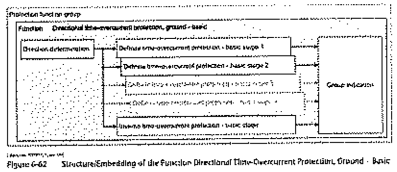

Figure 6-62 Structure/Embedding of the Function Directional Time-Overcurrent Protection, Ground – Basic

If the following listed device-internal functions are present in the device, these functions can influence the pickup values and operate delays of the stages or block the stages. The stage can also be affected by an external source via a binary input signal.

- Automatic reclosing (AREC)
- Cold-load pickup detection
- Binary input signal

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

6.7.3 General Functionality

6.7.3.1 Measured-Value Selection

Logic

The function provides the option to select between the values IN measured or 3I0 calculated.

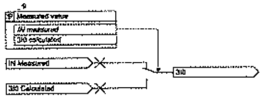

Figure 6-63 Logic Diagram of Measured-Value Selection

Both options are only available for the current-transformer connection types 3-phase + IN and 3-phase + IN-separate. For other connection types respectively, only one option is possible. If you select an option that is not allowed, an inconsistency message is given.

Depending on the CT secondary rated current, the CT connection type, and the selected setting, the secondary threshold setting range varies according to the following table.

Table 6-5 Threshold Setting Range

Connection Type	Measured Value	CT Terminal Type	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 1 A, IN = 5 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 1 A)	Threshold Setting Range (rated I-sec.: ph = 5 A, IN = 5 A)
3ph + IN	3I0 calculated	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	N/A	N/A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	N/A	N/A	0.005 A to 8.000 A
3ph + IN-separate	3I0 calculated	4 * Protection	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.030 A to 35.000 A	0.030 A to 35.000 A	0.15 A to 175.00 A	0.15 A to 175.00 A
		4 * Measurement	0.001 A to 1.600 A	0.001 A to 1.600 A	0.005 A to 8.000 A	0.005 A to 8.000 A
	IN measured	4 * Protection	0.030 A to 35.000 A	0.15 A to 175.00 A	0.030 A to 35.000 A	0.15 A to 175.00 A
		3 * Protection, 1 * sen.	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A
		4 * Measurement	0.001 A to 1.600 A	0.005 A to 8.000 A	0.001 A to 1.600 A	0.005 A to 8.000 A

6.7.3.2 Direction Determination

Logic of Direction Determination

The following figure represents the logic of the direction determination. It applies to all types of stages.

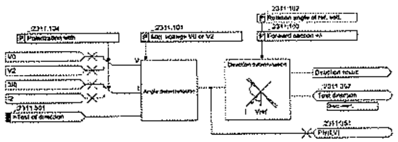

Figure 6-64 Logic Diagram of Direction Determination

Measurand for the Direction Determination

With the parameter Polarization with you define whether the direction determination is calculated with the zero-sequence components 3I0 and V0 or with the negative-sequence components I2 and V2, which are present during faults in the network.

The angle between IN (=-3I0) and V0 (respectively -I2 and V2) in case of using the negative-sequence components is available as a functional measured value. This value is only present during faults in the network.

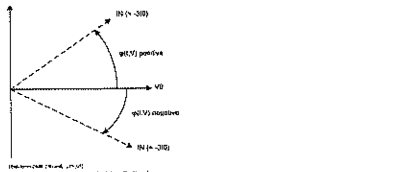

Figure 6-65 Measured-Value Definition

Start of the Direction Determination

If the zero-sequence current 3I0 exceeds the pickup threshold of a stage and the selected voltage (V0 or V2) exceeds the parameter Min. voltage V0 or V2 as well, the direction determination is started.

Direction Determination with Zero-Sequence Values

The direction is determined by calculating the phase angle between the short-circuit current -3I0 and the rotated reference voltage Vref, rot. Contrary to the Directional time-overcurrent protection, phase function, which works with the healthy voltage as reference voltage, the fault voltage V0 itself is the reference voltage for the Directional time-overcurrent protection, ground function. To take different system condi-

tions and applications into account, the reference voltage V0 can be rotated through an adjustable angle (parameter Rotation angle of ref. volt.). This moves the vector of the rotated reference voltage close to the vector of the short-circuit current -3I0. Consequently, the result of direction determination is as reliable as possible. Figure 6-66 illustrates the relationship based on a 1-phase-to-ground fault in phase A. The fault current has a phase displacement of 180° to the fault current IscA and lags the fault voltage by the fault angle φsc. The reference voltage V0 is rotated by φrot which is -45°.

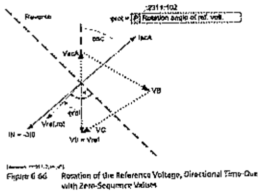

Figure 6-66 Rotation of the Reference Voltage, Directional Time-Overcurrent Protection, Ground Function with Zero-Sequence Values

The rotated reference voltage Vref, rot and the parameter Forward section +/- define the forward and reverse ranges, see Figure 6-67. The forward range is calculated as ± Δφ around the rotated reference voltage Vref, rot. Δφ is set with the parameter Forward section +/-. If the short-circuit current vector -3I0 is located in this range, the device decides on the forward direction. In the mirrored range, the device decides on the reverse direction. In the intermediate range, the direction is undetermined.

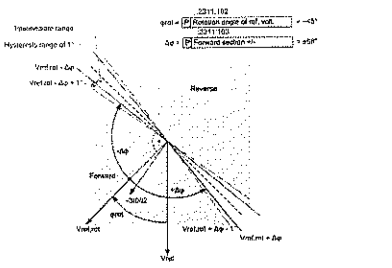

Figure 6-67 Forward/Reverse Characteristic of the Directional Time-Overcurrent Protection, Ground Function

Direction Determination with Negative-Sequence Values

The method works in the same way as for zero-sequence values. Instead of 3I0 and V0, the negative-sequence values I2 and V2 are used for determining the direction.

Direction Determination for Test Purposes

If you activate the binary input signal *>Test of direction*, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. The direction can be determined as soon as the zero-sequence current 3I0 and the zero-sequence voltage V0 exceeds approx. 7 % of the secondary rated values of phase current and voltage.

6.7.3.3 Application and Setting Notes

Parameter: Measured value

- Recommended setting value (_:9) Measured value = IN Measured

This parameter is not available in the basic function.

Parameter Value	Description
IN Measured	The function operates with the measured ground current IN. This is the recommended setting unless there is a specific reason to use the calculated zero-sequence current 3I0.
3I0 Calculated	The function operates with the calculated zero-sequence current 3I0. This setting option can be used when applying a redundant 50N/51N function for safety reasons.

Parameter: Min. voltage V0 or V2

- Recommended setting value (_:2311:101) Min. voltage V0 or V2 = 2 V

This parameter is not available in the basic function. The basic function uses a fixed value of 2 V.

You use the Min. voltage V0 or V2 parameter to define the minimum zero-sequence voltage or negative-sequence voltage for the direction determination. The minimum voltage must be set greater than the maximum operational unbalance plus the voltage-transformer measuring errors.

As the measuring error of the individual voltage transformer is not added up, the critical measuring-error influence is the unbalance of the primary system.

Siemens recommends observing the operational zero-sequence voltage V0 of the protected object (for example, the line) via the operational measured values of the device and providing the maximum value with a certainty of 50 %.

EXAMPLE

Maximum operational measured value of zero-sequence voltage V0 = 0.5 Vsec
Min. voltage V0 or V2 = 1.5 * 0.5 V = 0.75 Vsec

If you have no information about maximum operational unbalance, Siemens recommends using the default setting.

Parameter: Rotation angle of ref. volt. / Forward section +/-

- Recommended setting value (_:2311:102) Rotation angle of ref. volt. = -45°
- Recommended setting value (_:2311:103) Forward section +/- = 88°

The parameter Forward section +/- is not available in the basic function. The basic function uses a fixed value of 88°.

The direction characteristic, that is, the area of the forward and reverse ranges, is set with the Rotation angle of ref. volt. and the Forward section +/- parameters. The short-circuit angle is typically to be found in a range from -30° to -60° inductively. Therefore, in most cases, the default setting of -45° can be retained to position the reference voltage, as it ensures a reliable directional result.

Some example settings for special applications appear below Table 6-6. Note that for 1-phase-to-ground faults (PG faults), the reference voltage is the zero-sequence voltage V0. This results in the following setting for the rotation angle:

Rotation angle of ref. volt. = -φk ground-measuring elements (PG faults)

Table 6-6 Example Settings

Application	φk Typical	Setting Rotation angle of ref. volt.
Power-flow direction Overhead line SIPROTEC	60°	-60°
Power-flow direction Underground line SIPROTEC	30°	-30°
Power-flow direction Transformer infeed SIPROTEC Assuming that underground lines are used SIPROTEC	30°	30°

Parameter: Polarization with

- Recommended setting value (_:2311:104) Polarization with = zero sequence

This parameter is not available in the basic function. The basic function uses always zero-sequence components for the direction determination.

You use the parameter Polarization with to select the values for the direction determination.

Parameter Value	Description
zero sequence	Select zero sequence to determine the direction via the zero-sequence components V0 and 3I0. Siemens recommends using the zero-sequence components for the direction determination.
negative sequence	Select negative sequence to determine the direction via the negative-sequence components V2 and I2. The negative-sequence system can be used in case of danger that the zero-sequence voltage is too small due to unfavorable zero-sequence impedance conditions or that a parallel line influences the zero-sequence system.

Input Signal: >Test of direction

If you activate the binary input signal *>Test of direction*, the direction is determined and indicated even without the current threshold being exceeded in one of the stages. This provides an easy means of checking the direction during commissioning, without changing the threshold values of the stages.

6.7.3.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:9	General:Measured value		• 3I0 calculated • IN measured	IN measured
_:101	General:Min. voltage V0 or V2		0.150 V to 20.000 V	2.000 V
_:102	General:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °
_:103	General:Forward section +/-		0 ° to 90 °	88 °
_:104	General:Polarization with		• zero sequence • negative sequence	zero sequence

6.7.3.5 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:501	General:>Test of direction		I
_:2311:352	General:Test direction		O
_:2311:351	General:Phi(I,V)		O

6.7.4 Stage Control

6.7.4.1 Description

Logic

The following figure represents the stage control. It applies to all types of stages.

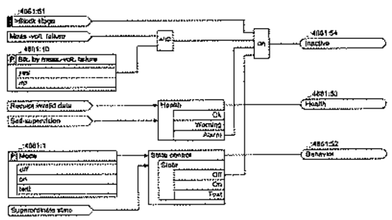

Figure 6-68 Logic Diagram of the Stage Control

Blocking of Stage in Case of Measuring-Voltage Failure

The stages can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From an internal source on the pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal *>Open* of the function block **Voltage-transformer circuit breaker**, which links to the trip of the voltage-transformer circuit breaker

The Blk. by meas.-volt. failure parameter can be set to either block or not block the stage when the **Measuring-voltage failure detection** function picks up.

6.7.4.2 Application and Setting Notes

Parameter: Blk. by meas.-volt. failure

- Recommended setting value (_:4861:10) Blk. by meas.-volt. failure = yes

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

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

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

Parameter Value	Description
yes	The directional overcurrent-protection stage is blocked when a measuring-voltage failure is detected. Siemens recommends using the default setting, as correct direction determination cannot be guaranteed if a measuring-voltage failure occurs.
no	The directional overcurrent-protection stage is not blocked when a measuring-voltage failure is detected.

6.7.5 Stage with Definite-Time Characteristic Curve

6.7.5.1 Description

Logic of the Basic Stage

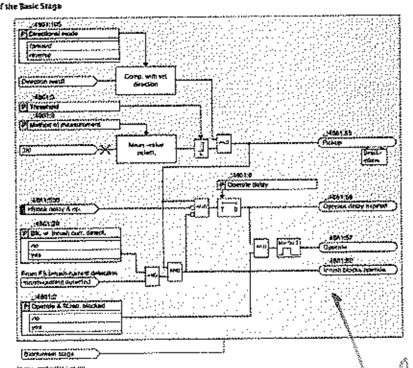

Figure 6-69 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Basic

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Logic of the Advanced Stage

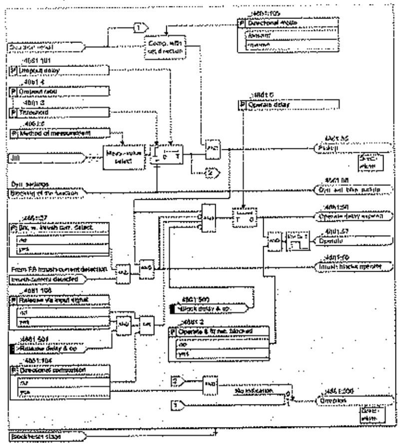

Figure 6-70 Logic Diagram of the Directional Definite Time-Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the Measuring point I-3ph, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 Threshold range varies according to the following table.

Table 6-7 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3 phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
3 ph + IN	Measured	4 * Protection	0.030 A to 35.000 A
3 ph + IN-separate		3 * Protection, 1 * sensitive	0.001 A to 1.600 A
		4 * Measurement	0.001 A to 1.600 A

Method of Measurement (Basic and Advanced Stage)

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

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

Directional Mode (Basic and Advanced Stage)

You can use the Directional mode parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see chapter 6.7.3.2 Direction Determination).

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal >Block stage (see chapter 6.7.4.1 Description)
- Measuring-voltage failure (see chapter 6.7.4.1 Description)
- Via the dynamic settings functionality, (only available in the advanced function type, see Influence of Other Functions via Dynamic Settings and chapter 6.7.10 Influence of Other Functions via Dynamic Settings)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal >Block delay & op. to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated. Fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter 6.5.7.1 Description.

Dropout Delay (Advanced Stage)

In case of undershooting of the dropout threshold, the dropout can be delayed. The pickup is maintained for the specified time. The operate delay continues to run. If the operate delay expires while the pickup is still maintained, the stage operates.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the Directional comparison parameter. With the yes setting, the direction indication Direction is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indication is independent of the directional mode set for the stage.

The Release via input signal parameter and the >Release delay & op. input signal are available with directional comparison protection. If the Release via input signal parameter is set to yes, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the >Release delay & op. input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold-load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.7.10 Influence of Other Functions via Dynamic Settings.

6.7.5.2 Application and Setting Notes

Parameter: Directional mode

- Default setting (_:4861:105) Directional mode = forward

You can use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value (_:4861:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: Directional comparison, Release via input signal

- Default setting (_:4861:104) Directional comparison = no
- Default setting (_:4861:106) Release via input signal = no

The parameters Directional comparison and Release via input signal are not visible for the basic stage.

You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the Direction and >Release delay & op. signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.
yes	If the Directional comparison parameter is set to yes, the Release via input signal parameter, the Direction output signal, and the >Release delay & op. input signal become available. If the Release via input signal parameter is set to yes, the starts of the operate delay and operate signal are only enabled when the >Release delay & op. input signal is active. The >Release delay & op. input signal must be connected to the enable information from the opposite end (forward information from the Direction output signal). See also the application example in chapter 6.6.10 Application Notes for Directional Comparison Protection.

Parameter: Dynamic settings

- Default setting (_:4861:26) Dynamic settings = no

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (Automatic reclosing or Cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to yes. This makes the configuration parameters affected by Auto reclosing/Cold-load PU/Binary input as well as the dynamic settings Threshold, Operate delay, and Stage blocked of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter 6.5.8.2 Application and Setting Notes (Advanced Stage) of the function Overcurrent Protection, Ground.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:4861:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short circuit voltage Vsc of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.
yes	When the transformer inrush current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stage, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Threshold

- Default setting (_:4861:3) Threshold = 1.20 A

For setting the threshold value, the same considerations apply as for the non-directional time-overcurrent protection function.

For further information, refer to chapter 6.5.4.2 Application and Setting Notes .

Parameter: Dropout ratio

- Recommended setting value (_:4861:4) Dropout ratio = 0.95

This parameter is not visible for the basic stage.

The recommended setting value of 0.95 is appropriate for most applications.

For high-precision measurements, the setting value of the Dropout ratio parameter can be reduced, for example to 0.98. If you expect highly fluctuating measurands at the pickup threshold, you can increase the setting value of the Dropout ratio parameter. This avoids chattering of the stage.

Parameter: Dropout delay

- Recommended setting value (_:4861:101) Dropout delay = 0 s

This parameter is not visible for the basic stage.

Siemens recommends using the dropout delay of 0 s, since the dropout of a protection stage must be performed as fast as possible.

You can use the Dropout delay parameter ≠ 0 s to obtain a uniform dropout behavior if you use it together with an electromechanical relay. This is required for time grading. The dropout time of the electromechanical relay must be known for this purpose. Subtract the dropout time of your own device (see Technical data) and set the result.

Parameter: Operate delay

- Default setting (_:4861:6) Operate delay = 0.300 s (for the 1st stage)

The Operate delay to be set is derived from the time-grading chart that has been prepared for the system.

Typical examples of grading times are provided in sections 6.6.9 Application Notes for Parallel Lines and Cable Runs with Infeed at Both Ends and 6.6.10 Application Notes for Directional Comparison Protection.

6.7.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4861:1	Definite-T 1:Mode		• off • on • test	off
_:4861:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4861:105	Definite-T 1:Directional mode		• forward • reverse	forward
_:4861:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4861:104	Definite-T 1:Directional comparison		• no • yes	no
_:4861:106	Definite-T 1:Release via input signal		• no • yes	no
_:4861:10	Definite-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4861:26	Definite-T 1:Dynamic settings		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4861:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4861:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:4	Definite-T 1:Dropout ratio		0.90 to 0.99	0.95
_:4861:101	Definite-T 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:4861:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.s: AR off/n.rdy				
_:4861:28	Definite-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4861:35	Definite-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4861:29	Definite-T 1:Effected by AR cycle 1		• no • yes	no
_:4861:36	Definite-T 1:Stage blocked		• no • yes	no
_:4861:14	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:20	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 2				
_:4861:30	Definite-T 1:Effected by AR cycle 2		• no • yes	no
_:4861:37	Definite-T 1:Stage blocked		• no • yes	no
_:4861:15	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4861:21	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
Dyn.set: AR cycle 3				
_:4861:31	Definite-T 1:Effected by AR cycle 3		• no • yes	no

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Addr.	Parameter	C	Setting Options	Default Setting
_:4861:10	Definite-T 1:Stage blocked		• no • yes	no
_:4861:16	Definite-T 1:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:4861:22	Definite-T 1:Operate delay		0,00 s to 60,00 s	0,30 s
Dyn.s: AR cycle>3				
_:4861:32	Definite-T 1:Effected by AR cycl.gr. 3		• no • yes	no
_:4861:39	Definite-T 1:Stage blocked		• no • yes	no
_:4861:17	Definite-T 1:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:4861:23	Definite-T 1:Operate delay		0,00 s to 60,00 s	0,30 s
Dyn.s: Cold Load PU				
_:4861:33	Definite-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4861:40	Definite-T 1:Stage blocked		• no • yes	no
_:4861:18	Definite-T 1:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:4861:24	Definite-T 1:Operate delay		0,00 s to 60,00 s	0,30 s
Dyn.set: bin.input				
_:4861:34	Definite-T 1:Effected by binary input		• no • yes	no
_:4861:41	Definite-T 1:Stage blocked		• no • yes	no
_:4861:19	Definite-T 1:Threshold	1 A @ 100 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 100 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 50 Irated	0,030 A to 35,000 A	1,200 A
		5 A @ 50 Irated	0,15 A to 175,00 A	6,00 A
		1 A @ 1,6 Irated	0,001 A to 1,600 A	1,200 A
		5 A @ 1,6 Irated	0,005 A to 8,000 A	6,000 A
_:4861:25	Definite-T 1:Operate delay		0,00 s to 60,00 s	0,30 s

6.7.5.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:Test of direction	SPS	I
_:2311:302	General:Test direction	ACD	O
_:2311:351	General:Pri(S,V)	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:4861:81	Definite-T 1:>Block stage	SPS	I
_:4861:501	Definite-T 1:>Release delay & op.	SPS	I
_:4861:84	Definite-T 1:>Activ. dyn. settings	SPS	I
_:4861:500	Definite-T 1:>Block delay & op.	SPS	I
_:4861:54	Definite-T 1:Inactive	SPS	O
_:4861:52	Definite-T 1:Behavior	ENS	O
_:4861:53	Definite-T 1:Health	ENS	O
_:4861:60	Definite-T 1:Inrush blocks operate	SPS	O
_:4861:62	Definite-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4861:63	Definite-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4861:64	Definite-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4861:65	Definite-T 1:Dyn.set. ARcycl.>3act	SPS	O
_:4861:66	Definite-T 1:Dyn.set. CLP active	SPS	O
_:4861:67	Definite-T 1:Dyn.set. BI active	SPS	O
_:4861:68	Definite-T 1:Dyn. set. blk. pickup	SPS	O
_:4861:55	Definite-T 1:Pickup	ACD	O
_:4861:300	Definite-T 1:Direction	ACT	O
_:4861:56	Definite-T 1:Operate delay expired	ACT	O
_:4861:57	Definite-T 1:Operate	ACT	O

6.7.6 Stage with Inverse-Time Characteristic Curve

6.7.6.1 Description

Logic of the Basic Stage

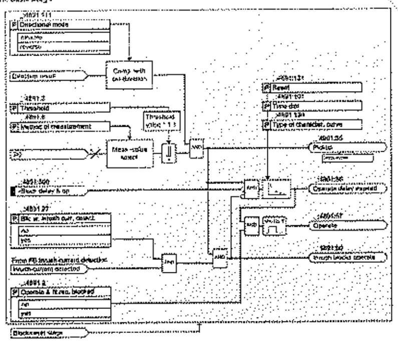

Figure 6-71 Logic Diagram of the Directional Inverse Time-Overcurrent Protection, Ground – Basic

Logic of the Advanced Stage

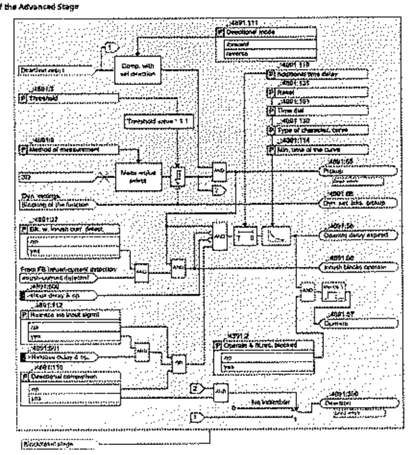

Figure 6-72 Logic Diagram of the Directional Inverse Time-Overcurrent Protection, Ground – Advanced

Measurand (Basic and Advanced Stage)

The function uses the zero-sequence current (3I0) as a criterion for the ground fault.

Depending on the parameter setting connection type of the **Measuring point I-3ph**, the zero-sequence current is measured or calculated. Depending on the applied CT terminal type, the 3I0 threshold range varies according to the following table.

Table 6-8 Threshold Setting Range

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary)
3-phase	Calculated	4 * Protection	0,030 A to 35,000 A
		3 * Protection, 1 * sensitive	0,030 A to 35,000 A
		4 * Measurement	0,001 A to 1,600 A
x + IN x + IN-separate	Measured	4 * Protection	0,030 A to 35,000 A
		3 * Protection, 1 * sensitive	0,001 A to 1,600 A
		4 * Measurement	0,001 A to 1,600 A

Method of Measurement (Basic and Advanced Stage)

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

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

Directional Mode (Basic and Advanced Stage)

You can use the **Directional mode** parameter to define whether the stage works in a forward or reverse direction.

The direction determination works across all stages (see chapter 6.7.3.2 Direction Determination).

Pickup and Dropout Behavior of the Inverse-Time Characteristic Curve According to IEC and ANSI (Basic and Advanced Stage)

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

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

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

Minimum Time of the Curve (Advanced Stage)

With the parameter **Min. time of the curve**, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.

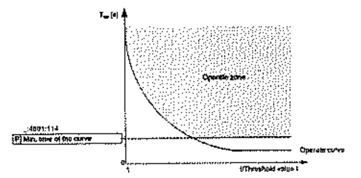

Figure 6-73 Minimum Operating Time of the Curve

Additional Time Delay (Advanced Stage)

With the parameter **Additional time delay**, you define a definite-time delay in addition to the inverse-time delay. With this setting, the whole curve is shifted on the time axis by this additional definite time.

Blocking of the Stage (Basic and Advanced Stage)

The following blockings reset the picked up stage completely:

- Externally or internally via the binary input signal *>Block stage* (see chapter 6.7.4.1 Description)
- Measuring-voltage failure (see chapter 6.7.4.1 Description)
- Via the dynamic settings functionality (only available in the advanced function type, see Influence of Other Functions via Dynamic Settings and chapter 6.7.10 Influence of Other Functions via Dynamic Settings)

Blocking of the Operate Delay (Basic and Advanced Stage)

You can use the binary input signal *>Block delay & op.* to prevent the start of the operate delay and thus also the generation of the operate signal. A running operate delay is reset. The pickup is indicated, fault logging and fault recording take place.

Blocking of the Operate Delay and Operate Signal via the Device-Internal Inrush-Current Detection Function (Basic and Advanced Stage)

Blocking of the operate delay and the operate signal via the device-internal inrush-current detection function is described in chapter Blocking of the Tripping by Device-Internal Inrush-Current Detection

For more information, refer to 6.5.7.1 Description.

Directional Comparison Protection (Advanced Stage)

The stage can be used for directional comparison protection. This is set using the **Directional comparison** parameter. With the **yes** setting, the direction indication *Direction* is released and the direction (forward or reverse) is determined, if the current exceeds the threshold of the stage. The direction indicated is independent of the directional mode set for the stage.

The **Release via input signal** parameter and the *>Release delay & op.* input signal are available with directional comparison protection. If the **Release via input signal** parameter is set to **yes**, the start of the operate delay, and therefore the operate signal of the stage, are only enabled when the *>Release delay & op.* input signal is active.

Influence of Other Functions via Dynamic Settings (Advanced Stage)

If available in the device, the following functions can exert an influence on the overcurrent-protection stage:

- Automatic reclosing
- Cold load pickup detection
- Binary input signal

The influence of these functions via dynamic settings is described in chapter 6.7.10 Influence of Other Functions via Dynamic Settings.

6.7.6.2 Application and Setting Notes

Parameter: Directional mode

- Default setting (_:4891:111) Directional mode = forward

You can use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
forward	Select this setting if the stage is to work in forward direction (in the direction of the line).
reverse	Select this setting if the stage is to work in reverse direction (in the direction of the busbar).

Parameter: Method of measurement

- Recommended setting value (_:4891:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard process.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks).

Parameter: Directional comparison, Release via input signal

- Default setting (_:4891:110) Directional comparison = no
- Default setting (_:4891:112) Release via input signal = no

The parameters Directional comparison and Release via input signal are not visible for the basic stage.
You can use these settings to define whether the stage is to be used for directional comparison protection. Directional comparison protection is performed via the Direction and >Release delay & op. signals.

Parameter Value	Description
no	The stage is not used for directional comparison protection.

Parameter Value	Description
yes	If the Directional comparison parameter is set to yes, the Release via input signal parameter, the Direction output signal, and the >Release delay & op. input signal become available. If the Release via input signal parameter is set to yes, the starts of the operate delay and operate signal are only enabled when the >Release delay & op. input signal is active. The >Release delay & op. input signal must be connected to the release information from the opposite end (forward information from the Direction output signal). See also the application example in chapter 6.6.10 Application Notes for Directional Comparison Protection.

Parameter: Dynamic settings

- Default setting (_:4891:26) Dynamic settings = no

This parameter is not visible for the basic stage.

Parameter Value	Description
no	The influence on the overcurrent-protection stage by device-internal or external functions is not necessary.
yes	If a device-internal function (Automatic reclosing or Cold-load pickup detection) or an external function should affect the overcurrent-protection stage (such as change the setting of the threshold value or operate delay, blocking of the stage), the setting must be changed to yes. This makes the configuration parameters effected by Auto reclosing/ Cold-load PU/Binary input as well as the dynamic settings Threshold, Time dial, and Stage blocked of the stage visible and enables the settings to be set for the specific influence.

For further setting notes, refer to chapter 6.5.8.2 Application and Setting Notes (Advanced Stage) of the function Overcurrent Protection, Ground.

Parameter: Blk. w. inrush curr. detect.

- Default setting (_:4891:27) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: • In cases where the device is not used on transformers. • In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer. This applies, for example, to the high-current stage that is set according to the short-circuit voltage V_{sc} of the transformer in such a way that the stage only picks up on faults from the high-voltage side. The transformer inrush current cannot become larger than the maximum transmittable short-circuit current.

Parameter Value	Description
yes	When the transformer inrush-current detection detects an inrush current that would lead to an operate of the stage, the start of the operate delay and operate of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer. This applies to the overcurrent-protection stages, which is used as a backup stage with grading time for faults on the undervoltage side of the transformer.

Parameter: Min. time of the curve

- Default setting (_:4891:114) Min. time of the curve = 0.00 s

This parameter is only available in the advanced stage.
With the parameter Min. time of the curve, you define a minimum operate delay time. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time. If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.
This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommends keeping the default setting of 0 s.

> **NOTE**
> If the set value is smaller than the smallest possible time delay of the inverse-time characteristic curve, the parameter has no influence on the delay time.

Parameter: Additional time delay

- Default setting (_:4891:115) Additional time delay = 0.00 s

With the parameter Additional time delay, you define a definite-time delay in addition to the inverse-time delay.
If the setting is left on its default value of 0 s, this parameter has no effect on the inverse-time characteristic curve.
This parameter is only required for time coordination in recloser schemes. For all other applications, Siemens recommend keeping the default setting of 0 s.

Parameter: Threshold

- Default setting (_:4891:3) Threshold = 1.20 A

The setting depends on the minimal occurring ground-fault current. This must be detected.
Consider that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the Threshold.

Parameter: Type of character. curve

- Default setting (_:4891:130) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application.

Parameter: Time dial

- Default setting (_:4891:101) Time dial = 1

You can use the Time dial parameter to displace the characteristic curve in the time direction.
The setting value for the Time dial parameter is derived from the time-grading chart that has been prepared for the electrical power system.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1 (default setting).

Parameter: Reset

- Default setting (_:4891:131) Reset = disk emulation

You can use the Reset parameter setting to define whether the stage decreases according to the dropout characteristic curve (in accordance with the behavior of a disk emulation = rotor disk) or instantaneously.

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

6.7.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:4891:1	Inverse-T 1:Mode		• off • on • test	off
_:4891:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:4891:111	Inverse-T 1:Directional mode		• forward • reverse	forward
_:4891:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:4891:110	Inverse-T 1:Directional comparison		• no • yes	no
_:4891:112	Inverse-T 1:Release via input signal		• no • yes	no
_:4891:10	Inverse-T 1:Blk. by meas.-volt. failure		• no • yes	yes
_:4891:26	Inverse-T 1:Dynamic settings		• no • yes	no
_:4891:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:4891:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:130	Inverse-T 1:Type of character. curve			
_:4891:114	Inverse-T 1:Min. time of the curve		0.00 s to 1.00 s	0.00 s
_:4891:131	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:4891:101	Inverse-T 1:Time dial		0.00 to 15.00	1.00
_:4891:115	Inverse-T 1:Additional time delay		0.00 s to 60.00 s	0.00 s

Addr.	Parameter	C	Setting Options	Default Setting
Dyn.s: AR off/n.rdy				
_:4891:28	Inverse-T 1:Effect. by AR off/n.ready		• no • yes	no
_:4891:35	Inverse-T 1:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:4891:29	Inverse-T 1:Effected by AR cycle 1		• no • yes	no
_:4891:36	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:14	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:102	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 2				
_:4891:30	Inverse-T 1:Effected by AR cycle 2		• no • yes	no
_:4891:37	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:15	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:103	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: AR cycle 3				
_:4891:31	Inverse-T 1:Effected by AR cycle 3		• no • yes	no
_:4891:38	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:16	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:104	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: AR cycle>3				
_:4891:32	Inverse-T 1:Effected by AR cycle gr. 3		• no • yes	no
_:4891:39	Inverse-T 1:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:4891:17	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:105	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.s: Cold load PU				
_:4891:33	Inverse-T 1:Effect. b. cold-load pickup		• no • yes	no
_:4891:40	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:18	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:106	Inverse-T 1:Time dial		0.00 to 15.00	1.00
Dyn.set: bin.input				
_:4891:34	Inverse-T 1:Effected by binary input		• no • yes	no
_:4891:41	Inverse-T 1:Stage blocked		• no • yes	no
_:4891:19	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:4891:107	Inverse-T 1:Time dial		0.00 to 15.00	1.00

6.7.6.4 Information List

No.	Information	Data Class (Type)	Type
Inverse-T 1			
_:4891:81	Inverse-T 1:>Block stage	SPS	I
_:4891:501	Inverse-T 1:>Release delay & op.	SPS	I
_:4891:84	Inverse-T 1:>Activ. dyn. settings	SPS	I
_:4891:500	Inverse-T 1:>Block delay & op.	SPS	I
_:4891:54	Inverse-T 1:Inactive	SPS	O
_:4891:52	Inverse-T 1:Behavior	ENS	O
_:4891:53	Inverse-T 1:Health	ENS	O
_:4891:60	Inverse-T 1:Inrush blocks operate	SPS	O
_:4891:62	Inverse-T 1:Dyn.set. AR cycle1act.	SPS	O
_:4891:63	Inverse-T 1:Dyn.set. AR cycle2act.	SPS	O
_:4891:64	Inverse-T 1:Dyn.set. AR cycle3act.	SPS	O
_:4891:65	Inverse-T 1:Dyn.set. ARcycl.>3act	SPS	O

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No.	Information	Data Class (Type)	Type
_:4891:66	Inverse-T 1:Dyn.set. CLP active	SPS	O
_:4891:67	Inverse-T 1:Dyn.set. BI active	SPS	O
_:4891:68	Inverse-T 1:Dyn.set. blk. pickup	SPS	O
_:4891:59	Inverse-T 1:Disk emulation running	SPS	O
_:4891:55	Inverse-T 1:Pickup	ACD	O
_:4891:300	Inverse-T 1:Direction	ACD	O
_:4891:56	Inverse-T 1:Operate delay expired	ACT	O
_:4891:57	Inverse-T 1:Operate	ACT	O

6.7.7 Stage with Inverse Time-Overcurrent Protection with Logarithmic-Inverse Characteristic Curve

6.7.7.1 Description

Logic of the Stage

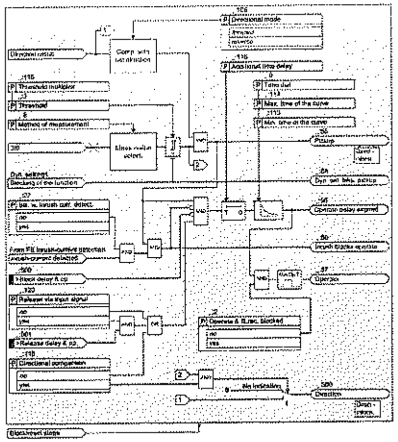

Figure 6-74 Logic Diagram of the Directional Logarithmic Inverse Time-Overcurrent Protection, Ground

Apart from the operate curve, this type of stage is identical to the Inverse time-overcurrent protection – advanced stage (see chapter 6.7.6.1 Description).

This section will only discuss the nature of the operate curve. For further functionality, refer to chapter 6.7.6.1 Description.

Operate Curve

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

The curve used to calculate the time value T_{op} is shown in the following figure. The Threshold multiplier parameter defines the beginning of the characteristic curve. The Max. time of the curve determines the initial value of the characteristic curve. The Time dial parameter changes the slope of the characteristic curve. At high currents, the Min. time of the curve parameter indicates the lower time limit.

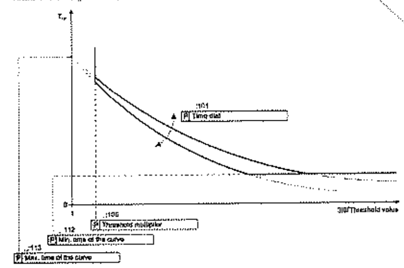

Figure 6-75 Operate Curve of Logarithmic Inverse-Time Characteristic

The time to operate is calculated with the following formula:

$$T_{op} = T_{max} - T_d \ln\left(\frac{3I0}{I_{thresh} \cdot I_{mul}}\right)$$

Where

T_{max}	Maximum time of the curve (parameter Max. time of the curve)
T_d	Time dial (parameter Time dial)
T_{op}	Operate time
3I0	Measured zero-sequence current
I_{thresh}	Threshold value (parameter Threshold)
I_{mul}	Threshold multiplier (parameter Threshold multiplier)

If the calculated time is less than T_{min} (parameter Min. time of the curve), T_{min} is used.

6.7.7.2 Application and Setting Notes

Apart from the operate curve, this type of stage is identical to the ground-fault protection type with inverse-time delay according to IEC and ANSI (advanced function type) (see chapter 6.7.6.1 Description).

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 6.7.6.2 Application and Setting Notes.

Stage Type Selection

If the operate delay is to be dependent on the current level according to a logarithmic characteristic curve, select this stage type.

Dynamic Settings: Threshold

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

Define the pickup value corresponding to the application. In doing so, for time-graded stages, the settings of the superordinate and of the subordinate stages in the time-grading chart must be taken into consideration.

Parameter: Threshold multiplier

- Default setting (_:116) Threshold multiplier = 1.1

You can use the Threshold multiplier parameter to define the beginning of the characteristic curve on the current axis (in relation to the threshold value).

General information cannot be provided. Define the value corresponding to the application.

EXAMPLE

Threshold (Secondary current)	I_{thresh} = 1.2 A
Threshold multiplier	I_{mul} = 1.1
Pickup value (Secondary current)	I_{Pi} = 1.2 A x 1.1 = 1.32 A

Dynamic Settings: Time dial

- Default setting (_:6) Time dial = 1.250 s

You can use the Time dial parameter to change the slope of the characteristic curve.

General information cannot be provided. Define the value corresponding to the application.

Parameter: Max. time of the curve

- Default setting (_:114) Max. time of the curve = 5.800 s

The parameter Max. time of the curve determines the initial value of the characteristic curve (for 3I0 = Threshold).

General information cannot be provided. Define the value corresponding to the application.

Parameter: Min. time of the curve

- Default setting (_:113) Min. time of the curve 1.200 s

The parameter Min. time of the curve determines the lower time limit (at high currents).

General information cannot be provided. Define the value corresponding to the application.

Parameter: Additional time delay

- Recommended setting value (_:115) Additional time delay = 0 s

You can set an additional current-independent time delay. This additional delay is intended for special applications.

Siemens recommends setting this time to 0 s so that it has no effect.

6.7.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Log. inv. T #:Mode		• off • on • test	off
_:2	Log.-inv.-T #:Operate & flt.rec. blocked		• no • yes	no
_:119	Log.-inv.-T #:Directional mode		• forward • reverse	forward
_:8	Log.-inv. T #:Method of measurement		• fundamental comp. • RMS value	fundamental comp
_:118	Log.-inv.-T #:Directional comparison		• no • yes	no
_:120	Log.-inv.-T #:Release via input signal		• no • yes	no
_:10	Log.-inv.-T #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	Log.-inv.-T #:Dynamic settings		• no • yes	no
_:27	Log.-inv.-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	Log. inv. T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:6	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
_:113	Log.-inv.-T #:Min. time of the curve		0.000 s to 60.000 s	1.200 s
_:114	Log.-inv.-T #:Max. time of the curve		0.000 s to 60.000 s	5.800 s
_:116	Log. inv. T #:Threshold multiplier		1.00 to 4.00	1.10
_:115	Log.-inv.-T #:Additional time delay		0.000 s to 60.000 s	0.000 s
Dyn. s: AR off/n. rdy				
_:28	Log.-inv.-T #:Effect. by AR off/n. rdy		• no • yes	no
_:35	Log. inv. T #:Stage blocked		• no • yes	no
Dyn. set: AR cycle 1				
_:29	Log.-inv.-T #:Effected by AR cycle 1		• no • yes	no
_:36	Log.-inv.-T #:Stage blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:14	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:107	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn. set: AR cycle 2				
_:30	Log.-inv.-T #:Effected by AR cycle 2		• no • yes	no
_:37	Log.-inv.-T #:Stage blocked		• no • yes	no
_:15	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:108	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn. set: AR cycle 3				
_:31	Log.-inv.-T #:Effected by AR cycle 3		• no • yes	no
_:38	Log.-inv.-T #:Stage blocked		• no • yes	no
_:16	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:109	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn. s: AR cycle>3				
_:32	Log.-inv.-T #:Effected by AR cycle gr. 3		• no • yes	no
_:39	Log.-inv.-T #:Stage blocked		• no • yes	no
_:17	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	Log. inv. T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn. s: Cold load PU				
_:33	Log.-inv.-T #:Effect. b. cold-load pickup		• no • yes	no
_:40	Log. inv. T #:Stage blocked		• no • yes	no

ВЯРНО С ОРИГИНАЛА

ВАРНА VARNA

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Addr.	Parameter	C	Setting Options	Default Setting
_:18	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:111	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s
Dyn.sett: bin.input				
_:34	Log.-inv.-T #:Effected by binary input		• no • yes	no
_:41	Log.-inv.-T #:Stage blocked		• no • yes	no
_:19	Log.-inv.-T #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:112	Log.-inv.-T #:Time dial		0.000 s to 60.000 s	1.250 s

6.7.7.4 Information List

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

6.7.8 Stage Description Knee-Point Characteristic Curve

6.7.8.1 Description

Logic of the Stage

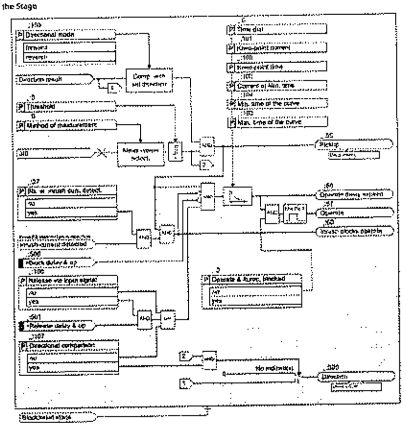

Figure 6-76 Logic Diagram of the Directional Logarithmic Inverse Time with Knee Point Overcurrent Protection, Ground

Apart from the operate curve, this type of stage is almost identical to the inverse time-overcurrent protection – advanced stage (see chapter 6.7.6.1 Description). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 6.7.6.1 Description.

Operate Curve

If the function picks up, the logarithmic inverse-time characteristic curve is processed. A time value T_{op} is calculated for every input value exceeding 95 % of the 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 slops. 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 3I0 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.

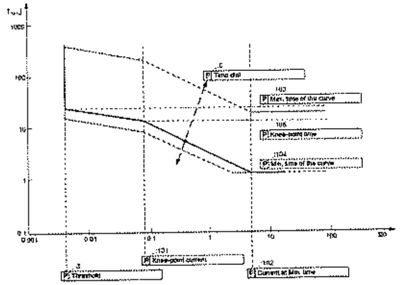

Figure 6-77 Operate Curve of the Logarithmic Inverse Time with Knee Point Characteristic (in the Example of Threshold = 0.004 A)

6.7.8.2 Application and Setting Notes

Apart from the operate curve, this type of stage is almost identical to the inverse time-overcurrent protection – advanced stage (see chapter 6.7.6.1 Description). The only difference is that the dynamic settings change functionality is not available.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 6.7.6.2 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 = 93.00 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.

6.7.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	Log.inv.T KP #:Mode		• off • on • test	off
_:2	Log.inv.T KP #:Operate & flt.rec. blocked		• no • yes	no
_: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
_:3	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

6.7.8.4 Information List

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

6.7.9 Stage with User-Defined Characteristic Curve

6.7.9.1 Description

Logic of the Stage

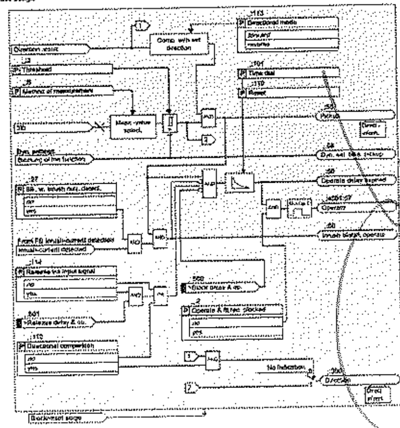

Figure 6-78 Logic Diagram of the Directional User Defined Characteristic Curve Overcurrent Protection, Ground

This stage is structured in the same way as the inverse time-overcurrent protection – advanced stage (see chapter 6.7.6.1 Description). The only difference is that you can define the characteristic curve.

This section only discusses the nature of the operate curve. For further functionality, refer to chapter 6.7.6.1 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.

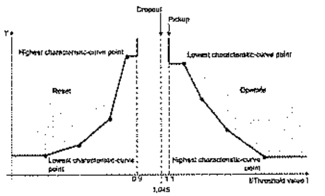

Figure 6-79 Pickup and Dropout Behavior when Using a User-Defined Characteristic Curve

> **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.

6.7.9.2 Application and Setting Notes

This stage is structured in the same way as the inverse time-overcurrent protection – advanced stage. The only difference is that you can define the characteristic curve as required. This section only provides application and setting notes for setting the characteristic curves. For guidance on the other parameters of the stage, see chapter 6.7.6.2 Application and Setting Notes.

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

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

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

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

> **NOTE**
>
> The value pairs must be entered in continuous order.

Parameter: Time dial

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

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

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

Parameter: Reset

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

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

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

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

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

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

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

> **NOTE**
>
> The value pairs must be entered in continuous order.

6.7.9.3 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 #:Operate & flt.rec. blocked		• no • yes	no
_:113	User curve #:Directional mode		• forward • reverse	forward
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:112	User curve #:Directional comparison		• no • yes	no
_:114	User curve #:Release via input signal		• no • yes	no
_:10	User curve #:Blk. by meas.-volt. failure		• no • yes	yes
_:26	User curve #:Dynamic settings		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.s: AR off/n.rdy				
_:28	User curve #:Effect. by AR off/n.ready		• no • yes	no
_:35	User curve #:Stage blocked		• no • yes	no
Dyn.set: AR cycle 1				
_:29	User curve #:Effected by AR cycle 1		• no • yes	no
_:36	User curve #:Stage blocked		• no • yes	no
_:14	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:102	User curve #:Time dial		0.05 to 15.00	1.00
Dyn.set: AR cycle 2				
_:30	User curve #:Effected by AR cycle 2		• no • yes	no
_:37	User curve #:Stage blocked		• no • yes	no

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

6.7.9.4 Information List

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

6.7.10 Influence of Other Functions via Dynamic Settings

6.5.8.1 Description and 6.5.8.2 Application and Setting Notes (Advanced Stage) describe the influence of other functions on dynamic settings.

ВЯРНО С ОРИГИНАЛА

6.8 Inrush-Current Detection

6.8.1 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

6.8.2 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.

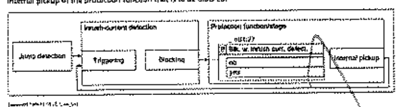

Figure 6-80 Structure/Embedding of the Function

6.8.3 Function Description

The function Inrush-current detection analyzes the trigger signal of the jump detection or the threshold-value violation of the function to be blocked in a start logic, and synchronizes the method of measurement. In order to securely record the inrush processes, the function uses the Harmonic analysis method of measurement and the CWA method (current wave shape analysis). Both methods work in parallel and link the results through a logical OR.

If you wish to work with only one process, deactivate the other method by way of the parameters Blocking with 2. harmonic or Blocking with CWA.

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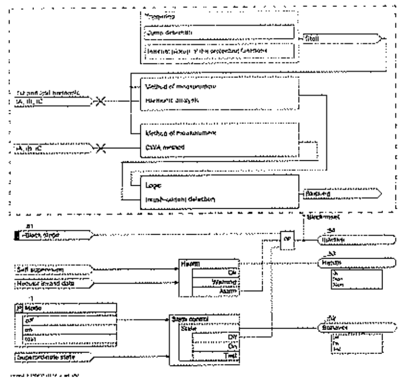

Figure 6-81 Basic Structure of the Inrush-Current Detection

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).

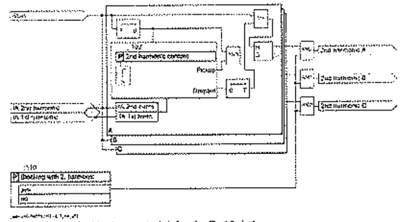

Figure 6-82 Logic of the Harmonic Analysis Function (T – 1 Period)

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.

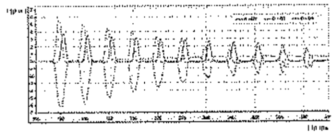

Figure 6-83 Inrush-Current Characteristic

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.

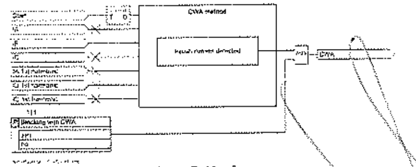

Figure 6-84 Logic of the CWA-Method Function (T = 1 Period)

Logic of the Inrush-Current Detection

The following logic diagram shows the link of the 2 methods of measurement **Harmonic Analysis** and **CWA method**.

The crossblock function influences the **Harmonic Analysis** process. If you have set the parameter `Cross-blocking` to `yes`, you will receive in the event of threshold value violation a blocking indication for all 3 phase currents and the measured or calculated zero-sequence current $I_{N/3I0}$ ($I_{N\ sens}$). 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.

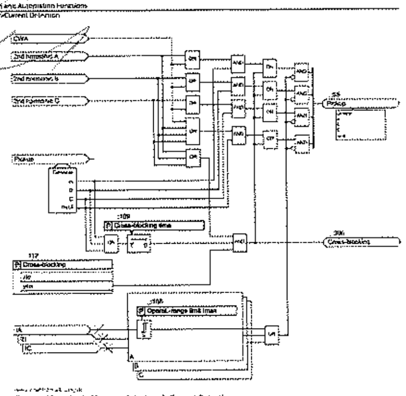

Figure 6-85 Logic Diagram of the Inrush-Current Detection

6.8.4 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 advised setting values.

Parameter: 2nd harmonic content

- Recommended setting value (_:107) `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 malfunction of the inrush-current detection is identified in the course of the closure trials during commissioning, set the parameter `Cross-blocking` to `yes`.

Parameter: Cross-blocking time

- Default setting (_:109) `Cross-blocking time = 0.06 s`

  You define the duration of this blocking with the `Cross-blocking time` parameter. The default setting of 0.06 s (about 3 periods) has proven practicable. Set the time as short as possible and check the value during the closure trials. The parameter `Cross-blocking time` is inactive at `Cross-blocking = no`.

Parameter: Start flt.rec

- Default setting (_:114) `Start flt.rec = yes`

  With the `Start flt.rec` parameter, you determine whether a fault record should be started upon pickup of the inrush-current detection. The following settings are possible:

Parameter Value	Description
no	No fault recording starts with pickup
yes	The fault recording starts with pickup. When the protection function is blocked by the inrush-current detection, a fault recording is started nevertheless.

6.8.5 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
_:107	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

6.8.6 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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6.9 Instantaneous High-Current Tripping

6.9.1 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.

6.9.2 Structure of the Function

The Instantaneous high-current tripping function offers 2 different increment types:

- Stage with standard release method
- Stage with release method via protection interface (only applicable if the device is equipped with a protection interface)

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

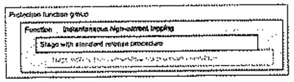

Figure 6-86 Structural Embedding of the Function

6.9.3 Standard Release Procedure

Logic

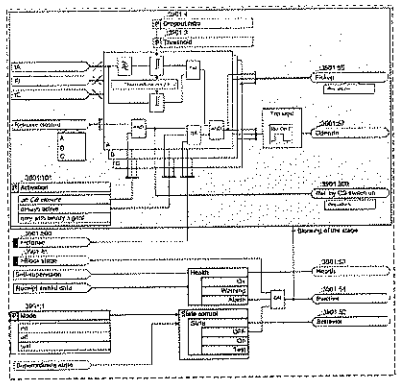

Figure 6-87 Logic Diagram of Instantaneous High-Current Tripping with Standard Release Method

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 way signals are generated Rel. by CB switch on is described in section 5.7.6 Circuit-Breaker Position Recognition for Protection-Related Auxiliary Functions.

- always active

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

- only with binary signal

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

Method of Measurement, Threshold Value

The stage works with 2 different methods of measurement.

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

6.9.4 Application and Setting Notes

Parameter: Activation

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

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

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

Parameter: Threshold

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

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

EXAMPLE

Calculation example for current grading of a 110 kV overhead line measuring 150 mm²

s (length) = 100 km;

R_1/s = 0.21 Ω/km;

X_1/s = 0.43 Ω/km

Since the stage is non-directional, the calculation must consider the maximum short-circuit power at the start of the line or at the opposite end:

S_{SC}" = 3.5 GVA (subtransient, because the function can respond to the 1st peak value)

Current transformer: 600 A/5 A

The line impedance Z_L and the minimum source impedance Z_S are calculated on this basis:

Line Impedance Z_L and Source Impedance Z_S: $Z_1/s = \sqrt{0.21^2 + 0.43^2}$ Ω/km = 0.479 Ω/km

Z_L = 0.479 Ω /km · 100 km = 47.9 Ω

$$Z_S = \frac{110\ kV^2}{3500\ MVA} = 3.46\ \Omega$$

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

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

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.

6.9.5 Release Procedure via Protection Interface

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

Logic

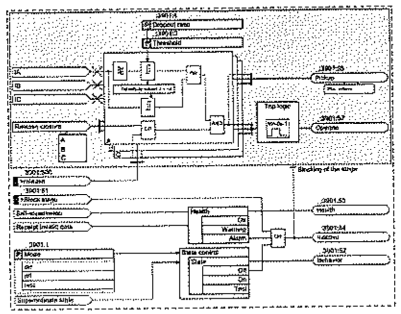

Figure 6-88 Logic Diagram of Instantaneous High-Current Tripping with Release Procedure via Protection Interface

Release

If one of the following conditions is fulfilled, the stage is released (the internal Release signal is present) (for further information, see chapter Process Monitor):

- 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 attempted.

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 jumpered).

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.

6.9.6 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.

6.9.7 Settings

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

6.9.8 Information List

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

4[illegible]3

No.	Information	Data Class (Type)	Type
_:4501:57	Group indicat.:Operate	ACT	O
Standard 1			
_:3901:501	Standard 1:>Release	SPS	I
_:3901:81	Standard 1:>Block stage	SPS	I
_:3901:54	Standard 1:Inactive	SPS	O
_:3901:52	Standard 1:Behavior	ENS	O
_:3901:53	Standard 1:Health	ENS	O
_:3901:300	Standard 1:Rel. by CB switch on	ACT	O
_:3901:55	Standard 1:Pickup	ACD	O
_:3901:57	Standard 1:Operate	ACT	O

6.10 Arc Protection

6.10.1 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

6.10.2 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.

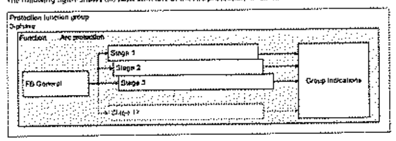

Figure 6-89 Structure/Embedding of the Arc Protection Function

6.10.3 Function Description

General Logic of the Function Block

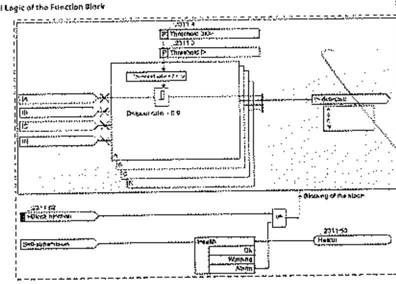

Figure 6-90 General Logic Diagram of the Function Block

Logic of the Stage

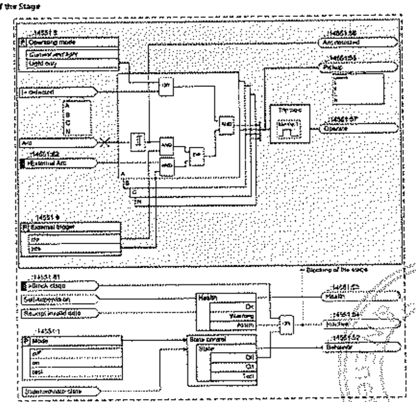

Figure 6-95 Logic Diagram of the Stage

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!

Within the Arc protection function, you can use a fast current-flow criterion as an additional release criterion. The parameters for the current-flow criterion can be found in the General block. For each stage, you can select individually whether the current-flow criterion must be evaluated as well.

Method of Measurement, Current-Flow Criterion

The current-flow criterion works with 2 different methods of measurement.

- Measurement of the fundamental component:
  This method of measurement processes the sampled current values and filters out the fundamental component numerically. A direct-current component is thus eliminated. The RMS value of the fundamental component is compared with the set threshold.
- Evaluation of the unfiltered measurand:
  If the current exceeds the threshold value set by the current amount ≥ 2 · √2 · threshold value, the stage uses additional unfiltered measurands. Thus, very short operate times are possible.

> **NOTE**
>
> If using the current-flow criterion in addition to the light, prevent a potential overfunction caused by the suddenly occurring light signal.
>
> If you use the current-flow criterion, arcs are typically detected in 4 ms.

Self Monitoring

The Arc protection function uses a self monitoring circuit. This circuit monitors the optical arc sensors and the fiber-optic cables. The arc-protection module uses the fiber-optic cable to send a cyclic test signal (light) to the arc sensors. If the channel is operating properly, the test signal is sent back to the arc protection module. If the test signal is not returned to the arc protection module, the indication *Channel # Sensor failure* is generated.

If the self-monitoring function detects a fault, the indication *Health* is set to *Alarm* and the stage/function is blocked

6.10.4 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 6.2.4.2 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 6.5.4.2 Application and Setting Notes

> **NOTE**
>
> If you set the parameter CT connection = 3-phase, 2 primary CT for the 3-phase current measuring point, the parameter Threshold 3I0> has no effect.

6.10.5 Application and Setting Notes for the Stage

Parameter: External trip initiation

- Default setting (_:14551:9) External trip initiation = no

Use 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.

ВЯРНО С ОРИГИНАЛА

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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.

6.10.6 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	

6.10.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:82	General:>Block function	SPS	I
_:2311:53	General:Health	ENS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:14551:81	Stage 1:>Block stage	SPS	I
_:14551:82	Stage 1:>External Arc	SPS	I
_:14551:54	Stage 1:Inactive	SPS	O
_:14551:52	Stage 1:Behavior	ENS	O
_:14551:53	Stage 1:Health	ENS	O
_:14551:58	Stage 1:Arc detected	SPS	O

No.	Information	Data Class (Type)	Type
_:14551:55	Stage 1:Pickup	ACD	O
_:14551:57	Stage 1:Operate	ACT	O
Stage 2			
_:14552:81	Stage 2:>Block stage	SPS	I
_:14552:82	Stage 2:>External Arc	SPS	I
_:14552:54	Stage 2:Inactive	SPS	O
_:14552:52	Stage 2:Behavior	ENS	O
_:14552:53	Stage 2:Health	ENS	O
_:14552:58	Stage 2:Arc detected	SPS	O
_:14552:55	Stage 2:Pickup	ACD	O
_:14552:57	Stage 2:Operate	ACT	O
Stage 3			
_:14553:81	Stage 3:>Block stage	SPS	I
_:14553:82	Stage 3:>External Arc	SPS	I
_:14553:54	Stage 3:Inactive	SPS	O
_:14553:52	Stage 3:Behavior	ENS	O
_:14553:53	Stage 3:Health	ENS	O
_:14553:58	Stage 3:Arc detected	SPS	O
_:14553:55	Stage 3:Pickup	ACD	O
_:14553:57	Stage 3:Operate	ACT	O

Informationen der Selbstüberwachung vom Lichtbogenschutz-Modul

No.	Information	Data Class (Type)	Type
channel 4			
_:397	channel 4:Sensor failure	SPS	O

6.10.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only

6.10.8.1 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:

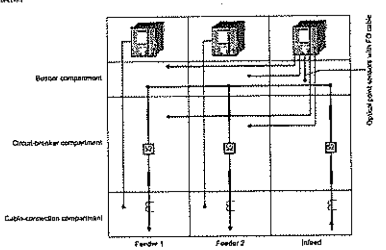

Figure 6-92 Layout and Connection of the Optical Point Sensors (Operating Mode = Light only)

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.

6.10.8.2 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 1

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 1

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

6.10.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current

6.10.9.1 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

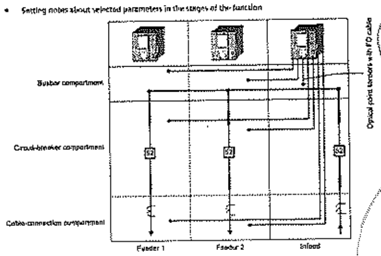

Figure 6-93 Layout and Connection of the Optical Point Sensors (Operation Mode = Current and Light)

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.

6.10.9.2 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 6.10.4 Application and Setting Notes – General Settings.

6.10.10 Application Example for Arc Protection with Point Sensors via External Trip Initiation

6.10.10.1 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

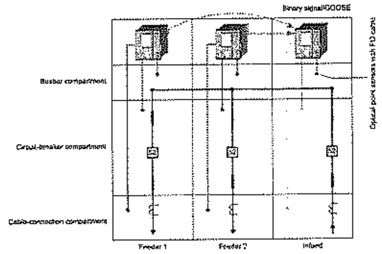

Figure 6-94 Arc Protection with External Trip Initiation

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 feeders, 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 6.10.10.2 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.

6.10.10.2 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 a CFC chart.

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 6-94), 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 6-94), 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

- 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.

6.10.11 Application Example for Arc Protection with a Line Sensor in Operating Mode: Light and Current

6.10.11.1 Description

Overview

The example describes the Arc protection function in a medium-voltage switchgear with 1 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 below:

- Optical line sensor placement in the switchgear
- Optical line sensor connection to the protection device in the infeed
- Number of necessary stages of the functions in the infeed protection device
- Setting notes about the selected parameters in the stages of the function

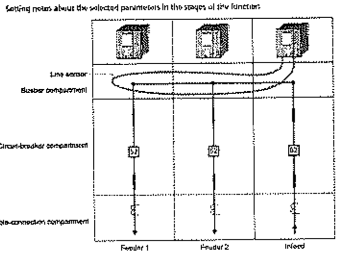

Figure 6-95 Layout and Connection of the Optical Line Sensors (Operating Mode = Current and Light)

For this example, the following is assumed:

- The current-flow criterion offers additional protection to prevent unwanted tripping caused by the sudden effects of light.
- Figure 6-95 shows how the optical line sensors should be routed. Start in the infeed busbar compartment and route the optical line sensor along the busbar and back again to the protection device in the infeed. Connect the optical line sensor to the protection device in the infeed.
- Depending on the routing options in the control cabinet, you can also route the optical line sensor through the circuit breaker and cable-connection compartments of the feeders.

  If this is not possible, you can detect arcs in these compartments using point sensors. For more detailed information, see chapters 6.10.8 Application Example for Arc Protection with Point Sensors in Operating Mode: Light Only and 6.10.9 Application Example for Arc Protection with Point Sensors in Operating Mode: Light and Current.
- If an arc occurs in the circuit-breaker compartment and in the cable-connection compartment of the infeed, the superordinate protection device will shut off.

NOTE

If the Arc protection function operates with the Operating mode = Current and light, the additional current-flow criterion will prevent unwanted tripping caused by external light effects.

NOTE

Note that the number of arc protection modules that are connected to the device depend on the hardware configuration of the equipment.

When using modular equipment, a maximum of 15 sensors can be connected. If using non-modular equipment, a maximum of 6 sensors (3 sensors per module) can be connected.

Depending on the use case, you can combine point and line sensors.

6.10.11.2 Application and Setting Notes

Setting Notes for the Protection Device in the Infeed

The Arc protection function operates with 1 stage.

Set the parameters of the stage as follows:

- Parameter: Operating mode = Current and light
- Parameter: Sensor = Line sensor
- Parameter: External trip initiation = no
- Parameter: Channel = Arc mod. 1 channel 1 (Stage 1) → Busbar compartment supervision (infeed, feeder 1, feeder 2)

You can find more information about the settings of the parameters Threshold I> and Threshold 3I0> in chapter 6.10.4 Application and Setting Notes – General Settings.

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6.11 Instantaneous Tripping at Switch onto Fault

6.11.1 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).

6.11.2 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.

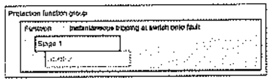

Figure 6-96 Structure/Embedding of the Function

6.11.3 Stage Description

Logic of the Stage

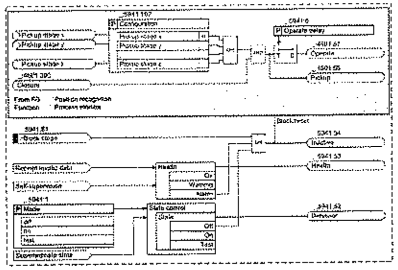

Figure 6-97 Logic Diagram of the Stage Instantaneous Tripping at Switch onto Fault

Connection of the Stage

The stage is intended to initiate instantaneous tripping when switching onto a fault. To do this, the stage must be connected to one or more pickups from protection functions or protection stages, for example, to pickup of an overcurrent protection stage. That is, the stage of the Instantaneous tripping at switch onto fault function does not have its own measuring function but requires the pickup of another protection function or protection stage to pick up.

The stage is active only if switching is pending or executed (for this, see section 6.3 Overcurrent Protection, Phases).

> **NOTE**
>
> If the pickup of a protection stage takes place and tripping is blocked by the inrush-current detection function, no pickup of the Instantaneous tripping at switch onto fault function takes place. In this case, there is no fault recording neither. Despite this, if a fault recording is necessary, you can activate it with the parameter (_:114) Start flt.rec. of the Inrush-current detection function (see chapter 6.8 Inrush-current Detection).

6.11.4 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:

- Distance Protection
- Overcurrent protection (phase and ground)
- Directional time overcurrent protection (phase and ground)

A specific protection stage is generally used. This can be one of the protection stages provided for the protection application, which itself trips with a delay. An additional protection stage with settings optimized for this use case, for example, increased threshold value and blocking of self-tripping, can also be used.

Parameter: Operate delay

- Recommended setting value (_:5941:6) Operate delay = 0.00 s

When switching onto a fault, the tripping should usually be instantaneous. The tripping delay is therefore set to 0.

6.11.5 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	

6.11.6 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

6.12 Overcurrent Protection, 1-Phase

6.12.1 Function Overview

The Overcurrent protection, 1-phase function (ANSI 50N/51N):

- Detects and monitors the current measured in a transformer neutral point grounding
- Can operate as sensitive tank leakage protection
- Detects and monitors the circulating current between the neutral points of 2 capacitor banks
- Switches off high-current faults instantaneously

6.12.2 Structure of the Function

The Overcurrent protection, 1-phase function is used in protection function groups with 1-phase current measurement. 2 function types are offered:

- **Overcurrent protection, 1-phase – advanced (50N/51N OC-1ph-A)**
- **Overcurrent protection, 1-phase – basic (50N/51N OC-1ph-B)**

The function type Basic is provided for standard applications. The function type Advanced offers more functionality and is provided for more complex applications.

Both function types are pre-configured by the manufacturer with 2 Definite time-overcurrent protection stages and with 1 Inverse time-overcurrent protection stage.

In the function type Overcurrent protection, 1-phase – advanced the following stages can be operated simultaneously:

- Maximum of 3 stages Definite time-overcurrent protection (UMZ)
- 1 stage Inverse time-overcurrent protection (AMZ)
- 1 stage User-defined characteristic curve overcurrent protection
- 1 Fast stage

In the function type Time-Overcurrent protection, 1-phase – basic, the following stages can operate simultaneously:

- Maximum of 3 stages Definite time-overcurrent protection
- 1 stage Inverse time-overcurrent protection

The non-preconfigured stages in Figure 6-98 and Figure 6-99 are shown in gray. Apart from the operate-delay characteristic curve, the Definite time-overcurrent protection stage, the Inverse time-overcurrent protection stage, and the User-defined characteristic curve time-overcurrent protection stage are structured identically.

The Fast stage uses a fast tripping algorithm. It is therefore suited in particular for sensitive ground-fault detection according to the high impedance principle.

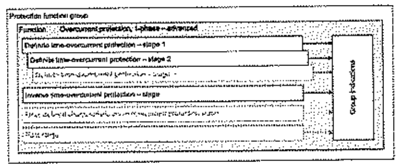

Figure 6-98 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Advanced

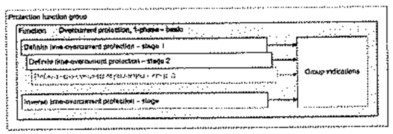

Figure 6-99 Structure/Embedding the Function Overcurrent Protection, 1-Phase – Basic

If the device is equipped with the Inrush-current detection function, you can stabilize the stages against issuing of the operate indication due to transformer inrush-currents.

6.12.3 Stage with Definite-Time Characteristic Curve

6.12.3.1 Description

Logic of a Stage

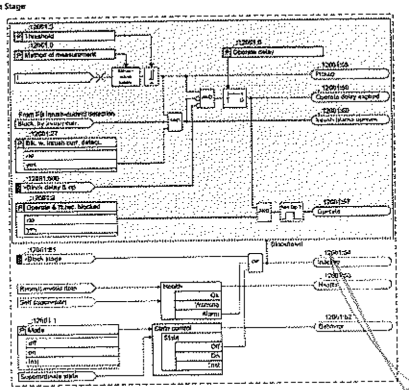

Figure 6-100 Logic Diagram of the Definite-Time Overcurrent Protection, 1-Phase

Method of measurement

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

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

Blocking of the Stage

The picked up stage can reset completely via the binary input signal >Block stage.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

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

With the Blk. w. inrush curr. detect. parameter, you can block the operate indication of the stage for a threshold-value violation due to the inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. When complete, the stage generates an operate indication. The blocking can only be set if the central function inrush-current detection is effective.

Blocking of tripping with the inrush-current detection function is possible only if the following conditions have been met:

- The central inrush-current detection function has to be available in another protection function group with 3-phase current measurement.
- You have to connect the protection function group with 1-phase current measurement to the protection function group with 3-phase current measurement. You connect protection function groups in the DIGSI 5 Project Tree → Name of the device → Function group connections

Related Topics

6.7.7.1 Description

6.12.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:12661:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Threshold, Operate delay

- Default setting (_:12661:3) Threshold = 1.200 A (for the first stage)
- Default setting (_:12661:6) Operate delay = 0.300 s (for the first stage)

Set the Threshold and Operate delay parameters for the specific application.

6.12.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Definite-T 1				
_:12661:1	Definite-T 1:Mode		• off • on • test	off
_:12661:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12661:27	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12661:8	Definite-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12661:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12661:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s

6.12.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:12661:81	Definite-T 1:>Block stage	SPS	I
_:12661:500	Definite-T 1:>Block delay & op.	SPS	I
_:12661:54	Definite-T 1:Inactive	SPS	O
_:12661:52	Definite-T 1:Behavior	ENS	O
_:12661:53	Definite-T 1:Health	ENS	O
_:12661:60	Definite-T 1:Inrush blocks operate	ACT	O
_:12661:55	Definite-T 1:Pickup	ACD	O
_:12661:56	Definite-T 1:Operate delay expired	ACT	O
_:12661:57	Definite-T 1:Operate	ACT	O

6.12.4 Stage with Inverse-Time Characteristic Curve

6.12.4.1 Description

Logic of the Stage

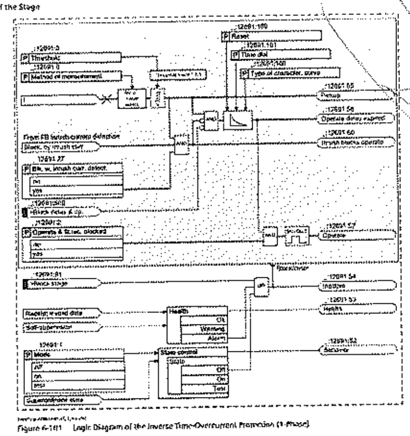

Figure 6-101 Logic Diagram of the Inverse-Time-Overcurrent Protection (1-Phase)

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

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

When the measured value falls short of the pickup value by a factor of 1.045 (0.95 × 1.1 × threshold value), the dropout is started. The pickup will be indicated as clearing. You can influence the dropout behavior via setting parameters. You can select between instantaneous dropout (totalized time is deleted) or dropout according to the characteristic curve (reduction of totalized time depending on the characteristic curve). The

dropout according to characteristic curve (disk emulation) is the same as turning back a rotor disk. The weighted reduction of the time is initiated from 0.9 of the set threshold value.

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

Method of Measurement

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

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

Blocking of the Stage

The picked up stage can reset completely via the binary input signal >Block stage.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also tripping. A running time delay is reset. The pickup is reported and a fault is opened.

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

With the Blk. w. inrush curr. detect. parameter, you can block the operate indication of the stage for a threshold-value violation due to the inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function signals this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started. When complete, the stage generates an operate indication.

Blocking of tripping with the inrush-current detection function is possible only if the following conditions have been met:

- The central inrush-current detection function has to be available in another protection function group with 3-phase current measurement.
- You have to connect the protection function group with 1-phase current measurement to the protection function group with 3-phase current measurement. You connect protection function groups in the DIGSI 5 Project Tree → Name of the device → Function group connections.

6.12.4.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:12691:8) Method of measurement = fundamental comp.

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 $I_{rated,sec}$.

Parameter: Type of character. curve

- Default setting (_:12691:108) Type of character. curve = IEC normal inverse

The device offers all the usual inverse-time characteristic curves according to IEC and ANSI. Select the Type of character. curve required for your specific application.

Parameter: Threshold

- Default setting (_:12691:3) Threshold = 1.20 A

Set the Threshold and Type of character. curve parameters for the specific application.

Note that a safety margin is set between pickup value and threshold value. The stage only picks up at approx. 10 % above the Threshold.

Parameter: Time dial

- Default setting (_:12691:101) Time dial = 1

Use the Time dial parameter to displace the characteristic curve in the time direction.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the parameter Time dial at 1 (default setting).

Parameter: Reset

- Default setting (_:12691:109) Reset = disk emulation

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

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

6.12.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Inverse-T 1				
_:12691:1	Inverse-T 1:Mode		• off • on • test	off
_:12691:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:12691:27	Inverse-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:12691:8	Inverse-T 1:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:12691:3	Inverse-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:12691:108	Inverse-T 1:Type of character. curve			

Addr.	Parameter	C	Setting Options	Default Setting
_:12691:109	Inverse-T 1:Reset		• instantaneous • disk emulation	disk emulation
_:12691:101	Inverse-T 1:Time dial		0.05 to 15.00	1.00

6.12.4.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:12691:81	Inverse-T 1:>Block stage	SPS	I
_:12691:500	Inverse-T 1:>Block delay & op.	SPS	I
_:12691:54	Inverse-T 1:Inactive	SPS	O
_:12691:52	Inverse-T 1:Behavior	ENS	O
_:12691:53	Inverse-T 1:Health	ENS	O
_:12691:60	Inverse-T 1:Inrush blocks operate	ACT	O
_:12691:59	Inverse-T 1:Disk emulation running	SPS	O
_:12691:55	Inverse-T 1:Pickup	ACD	O
_:12691:56	Inverse-T 1:Operate delay expired	ACT	O
_:12691:57	Inverse-T 1:Operate	ACT	O

6.12.5 Stage with User-Defined Characteristic Curve

6.12.5.1 Description

The User-defined characteristic curve time-overcurrent protection stage is only available in the advanced function type.

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired.

User-Defined Characteristic Curve

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

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

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

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

ВЯРНО С ОРИГИНАЛА

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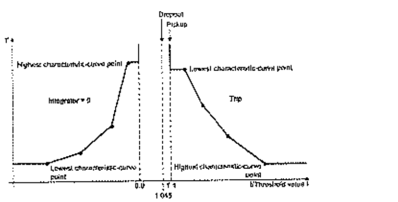

Figure 6-102 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

NOTE

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

6.12.5.2 Application and Setting Notes

This stage is structured the same way as the stage with the inverse-time characteristic curve. The only difference is that you can define the characteristic curve as desired. This chapter only provides application and setting notes for setting characteristic curves.

Parameter: Current/time value pairs (from the operate curve)

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

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

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

NOTE

The value pairs must be entered in continuous order.

Parameter: Time dial

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

Use the Time dial parameter to displace the characteristic curve in the time direction.

Where no time grading and therefore no displacement of the characteristic curve is required, leave the Time dial parameter at 1.

Parameter: Reset

- Default setting Reset = disk emulation

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

Parameter Value	Description
disk emulation	In the case of this setting, a dropout characteristic curve has to be set in addition to the operate curve. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a dropout after a disk emulation.
instantaneous	Use this setting if the dropout is not to be performed after disk emulation and an instantaneous dropout is desired instead.

Parameter: Current/time value pairs (of the dropout characteristic curve)

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

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

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

NOTE

The value pairs must be entered in continuous order.

6.12.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:27	User curve #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	User curve #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
_:3	User curve #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	6.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	6.000 A
_:110	User curve #:Reset		• instantaneous • disk emulation	disk emulation
_:101	User curve #:Time dial		0.05 to 15.00	1.00

6.12.5.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:500	User curve #:>Block delay & op.	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:60	User curve #:Inrush blocks operate	ACT	O
_:59	User curve #:Disk emulation running	SPS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O

6.12.6 Fast Stage

6.12.6.1 Description

Logic of a Stage

The fast stage is only available in function type Advanced.

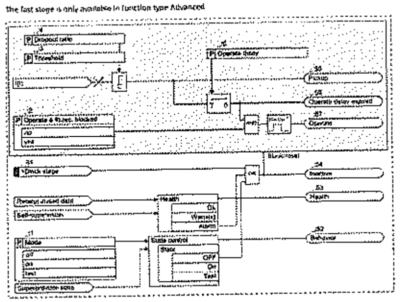

Figure 6-103 Logic Diagram of the Fast Stage, 1-Phase

Method of Measurement, Pickup and Dropout Behavior of the Fast Stage

This stage evaluates the unfiltered measurands. Thus, very short response times are possible. When the absolute values of 2 consecutive sampled values of the last half period exceed the Threshold, the stage picks up. When all sampled values of the previous period are less than the dropout threshold, the stage drops out.

Blocking of the Stage

The picked up stage can reset completely via the binary input signal >Block stage.

6.12.6.2 Application and Setting Notes

Parameter: Threshold, Operate delay

- Default setting (_:3) Threshold = 10.00 A
- Default setting (_:6) Operate delay = 0.00 s

Set the Threshold and Operate delay parameters for the specific application.

Ensure that the sampled values are compared directly without an additional factor with the set threshold value.

Parameter: Dropout ratio

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

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

6.12.6.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Fast stage #				
_:1	Fast stage #:Mode		• off • on • test	off
_:2	Fast stage #:Operate & flt.rec. blocked		• no • yes	no
_:3	Fast stage #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	10.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	50.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	10.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	50.000 A
_:4	Fast stage #:Dropout ratio		0.90 to 0.99	0.90
_:6	Fast stage #:Operate delay		0.00 s to 60.00 s	0.00 s

6.12.6.4 Information List

No.	Information	Data Class (Type)	Type
Fast stage #			
_:81	Fast stage #:>Block stage	SPS	I
_:54	Fast stage #:Inactive	SPS	O
_:52	Fast stage #:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:53	Fast stage #:Health	ENS	O
_:55	Fast stage #:Pickup	ACD	O
_:56	Fast stage #:Operate delay expired	ACT	O
_:57	Fast stage #:Operate	ACT	O

6.12.7 Application Example: High-Impedance Restricted Ground-Fault Protection

6.12.7.1 Description

With the high-impedance method, all current transformers operate in parallel at the limits of the protection range on a common, relatively high-impedance resistor R, the voltage of which is measured.

The current transformers must be of the same type of construction and have at least one core of their own for the high-impedance restricted ground-fault protection. Furthermore, they must have the same transfer ratio and approximately the same knee-point voltage.

The high impedance principle is especially suited for ground-fault detection in grounded networks at transformers, generators, motors, and shunt reactors.

The left part of Figure 6-104 shows an application example for a grounded transformer winding or a grounded motor/generator. The example at the right shows an ungrounded transformer winding or an ungrounded motor/generator. In this example, it is assumed that the network is grounded at a different point.

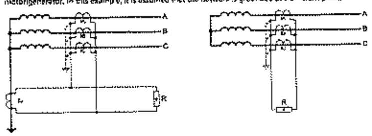

Figure 6-104 Restricted Ground-Fault Protection According to the High-Impedance Principle

Function of the High-Impedance Principle

The high-impedance principle is explained using the example of a grounded transformer winding.

In normal state, no residual currents flow, that is, in the transformer neutral point $I_Y = 0$ and in the phases $3I_0 = I_A + I_B + I_C = 0$.

With an external ground fault (on the left in Figure 6-105), the short-circuit current of which is fed via a grounded neutral point, the same current flows in the transformer neutral point and in the phases. The respective secondary currents (with the same transfer ratio of all current transformers) draw each other off. They are connected in series. At the resistor R, only a little voltage arises, which results from the internal resistances of the transformers and those of the transformer connection lines. Even if a current transformer is briefly saturated, it becomes a low impedance during the time of the saturation and forms a low-impedance shunt to the high-impedance resistor R. The high resistance of the resistor thus has a stabilizing effect (so-called resistor stabilization).

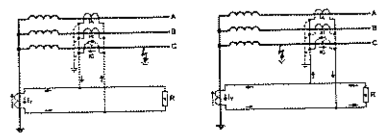

Figure 6-105 Principle of the Restricted Ground-Fault Protection According to the High-Impedance Principle

With a ground fault in the protection range (on the right in Figure 6-105), a neutral-point current I_Y flows in any case. The magnitude of the residual current in the phase currents depends on the grounding conditions in the rest of the network. A secondary current corresponding to the entire short-circuit current attempts to flow via the resistor R. But since this resistor is high-impedance, a high voltage arises there which causes the saturation of the current transformers. The effective voltage at the resistor therefore corresponds approximately to the knee-point voltage of the current transformers.

The resistor R is thus dimensioned in such a way that even the smallest ground-fault current to be detected leads to a secondary voltage that corresponds to half of the knee-point voltage of the current transformers (see chapter 2.5.4).

Further information can be found as Sensitivity view for high-impedance ground-fault differential protection in chapter 6.12.7.2 Application and Setting Notes.

High-Impedance Restricted Ground-Fault Protection with a SIPROTEC 5 Device

Use the I4 measuring input of the SIPROTEC 5 device for the high-impedance restricted ground-fault protection. This input for this application is to be executed as a sensitive measuring input. Since this is a current input, the current is detected by this resistor instead of the voltage at the resistor R.

Figure 6-106 shows the connection diagram. The protection device is connected in series with the resistor R and thus measures its current.

The varistor V limits the voltage in case of an internal fault. The varistor cuts the high instantaneous voltage peaks in the case of transformer saturation. Simultaneously, a smoothing of the voltage arises without any relevant reduction of the average value.

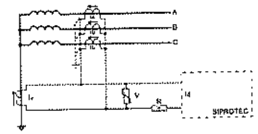

Figure 6-106 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

As a protection against overvoltages, it is important that you connect the device directly at the grounded side of the current transformers. The high voltage at the resistor is thus kept away from the device.

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In a similar manner, the high-impedance restricted ground-fault protection for generators, motors, and shunt reactors is used. With auto transformers, you must connect the upper voltage side and low voltage side current transformers and neutral point transformer in parallel.

The method can be realized for each protected object. As busbar protection, the device, for example, is connected via the resistor to the parallel connection of the transformers of all feeders.

6.12.7.2 Application and Setting Notes

A prerequisite for the application of the high-impedance restricted ground-fault protection is that neutral point current detection is possible on the station side (see example in (Figure 6-106)). Furthermore, a sensitive input transformer must be available at device input I4. Set the pickup value for current at input I4 with the function **Overcurrent protection, 1-phase**.

Observe the interaction between current transformer characteristic curve, external resistor R, and the voltage at R for the overall function of the high-impedance restricted ground-fault protection. Notes on this follow.

Current Transformer Data for High-Impedance Restricted Ground-Fault Protection

All affected current transformers must have the same ratio and approximately the same knee-point voltage. This is normally the case when the current transformers are of the same type and have the same rated data. You can calculate the knee-point voltage from the rated data as follows:

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2}\right) \cdot n \cdot I_{rated}$$

V_{KP}	Knee-point voltage
Ri	Internal resistance of the current transformer
P_{rated}	Rated power of the current transformer
I_{rated}	Secondary rated current of the current transformer
n	Rated overcurrent factor

Rated current, rated power, and overcurrent factor are found on the name plate of the transformer.

EXAMPLE

Current transformer with the following data on the name plate: 800/5; 5P10; 30 VA

You can read the following transformer data with this data:

I_{rated} = 5 A (out of 800/5)
n = 10 (out of 5P10)
P_{rated} = 30 VA

The internal resistance is frequently to be found in the test report of the transformer. If it is not known, it can be approximately determined by a direct current measurement at the secondary winding.

EXAMPLE

Calculation of the knee-point voltage
Current transformer 800/5; 5P10; 30 VA with R_i = 0.3 Ω

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2}\right) \cdot n \cdot I_{rated} = \left(0.3\ \Omega + \frac{30\ VA}{(5\ A)^2}\right) \cdot 10 \cdot 5\ A = 75\ V$$

Current transformer 800/1; 5P10; 30 VA with R_i = 5 Ω

$$V_{KP} = \left(R_i + \frac{P_{rated}}{I_{rated}^2}\right) \cdot n \cdot I_{rated} = \left(5\ \Omega + \frac{30\ VA}{(1\ A)^2}\right) \cdot 10 \cdot 1\ A = 350\ V$$

Besides the current-transformer data, the resistance of the longest connection line between transformers and device must be known.

Stability Consideration for High-Impedance Restricted Ground-Fault Protection

The stability condition is based on the simplified assumption that one current transformer is completely saturated and the others transfer their partial currents proportionately in the case of an external fault. This is theoretically the worst case. A safety margin is automatically provided, since, in practice, even the saturated transformer still delivers some current.

Figure 6-107 shows an equivalent circuit of this simplification. CT1 and CT2 are assumed to be ideal transformers with their internal resistances R_{i1} and R_{i2}. R_a are the core resistances of the connection lines between transformer and resistance R; they are used doubled (forward line and return line). R_{a2} is the resistance of the longest connection line.

CT1 transmits the current I1. CT2 is assumed to be saturated. This is indicated by the dotted short-circuit line. The transformer thus represents a low-impedance shunt by its saturation.

A further prerequisite is R >> (2R_{a2} + R_{i2}).

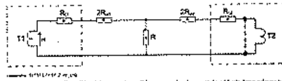

Figure 6-107 Simplified Connection Diagram of a Layout for High-Impedance Restricted Ground-Fault Protection

The voltage at R is, then,

$V_R = I_1 \cdot (2R_{a2} + R_{i2})$

A further assumption is that the pickup value of the SIPROTEC 5 device corresponds to half of the knee-point voltage of the current transformers. In the edge case,

$V_R = V_{KP}/2$

The stability limit I_{SL} results, which means the through-current up to which the arrangement remains stable:

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}}$$

EXAMPLE

For the 5-A transformer as above with V_{KP} = 75 V and R_i = 0.3 Ω

Longest connection line = 22 m with 4 mm² cross section; that corresponds to R_a = 0.1 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}} = \frac{37.5\ V}{2 \cdot 0.1\ \Omega + 0.3\ \Omega} = 75\ A$$

In the example, the stability limit is 15 x rated current or 12 kA primary.

For the 1-A transformer as above with V_{KP} = 350 V and R_i = 5 Ω

Longest connection line = 107 m with 2.5 mm² cross section; that corresponds to R_a = 0.75 Ω

$$I_{SL} = \frac{V_{KP}/2}{2 \cdot R_{a2} + R_{i2}} = \frac{175\ V}{2 \cdot 0.75\ \Omega + 5\ \Omega} = 27\ A$$

In the example, the stability limit is 27 x rated current or 21.6 kA primary.

Sensitivity Consideration for High-Impedance Restricted Ground-Fault Protection

The voltage present at the set of current transformers is supplied to the protection device via a series resistor R as proportional current for evaluation. For dimensioning of the resistor, the following must be taken into account:

The high-impedance restricted ground-fault protection should pick up at approximately half of the knee-point voltage of the current transformers. From this, you can calculate the resistor R.

Since the device measures the current through the resistor, the resistor and measuring input of the device must be connected in series. Since the resistor also should be high-impedance (aforementioned condition R >> 2R_{a2} + R_{i2}), the inherent resistance of the measuring input can be neglected. The resistance results thus from the pickup current I_{set} and half of the knee-point voltage:

$$R = \frac{V_{KP}/2}{I_{set}}$$

EXAMPLE

For the 5-A transformer as above
Desired pickup value I_{set} = 0.1 A (corresponds to 16 A primary)

$$R = \frac{V_{KP}/2}{I_{set}} = \frac{75\ V/2}{0.1\ A} = 375\ \Omega$$

For the 1-A transformer as above
Desired pickup value I_{set} = 0.05 A (corresponds to 40 A primary)

$$R = \frac{V_{KP}/2}{I_{set}} = \frac{350\ V/2}{0.05\ A} = 3500\ \Omega$$

The series resistor R must be designed for a minimum continuous load $P_{continuous}$:

$$P_{continuous} \geq \frac{(V_{KP}/2)^2}{R} = \frac{37.5^2}{375} = 3.75\ W \quad \text{at the 5-A-transformer}$$

$$P_{continuous} \geq \frac{(V_{KP}/2)^2}{R} = \frac{175^2}{3500} = 8.75\ W \quad \text{at the 1-A-transformer}$$

Further, the series resistor R must be designed for a fault current lasting approximately 0.5 s. This time is usually sufficient for fault clarification through backup protection.

The thermal stress of the series resistor depends on the voltage $V_{RMS,stab}$ that is present during an internal fault. It is calculated according to the following equations:

$$V_{RMS,stab} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{75^3 \cdot 375 \cdot 250} = 579.7\ V \quad \text{at the 5-A-transformer}$$

$$V_{RMS,stab} = 1.3 \cdot \sqrt[4]{V_{KP}^3 \cdot R \cdot I_{K,max,int}} = 1.3 \cdot \sqrt[4]{350^3 \cdot 3500 \cdot 50} = 2151.6\ V \quad \text{at the 1-A-transformer}$$

$I_{K,max,int}$ corresponds to the maximum fault current here in the case of an internal fault.

5-A current transformer 800/5 with 40 kA primary corresponds to $I_{K,max,int}$ = 250 A secondary.

1-A current transformer 800/1 with 40 kA primary corresponds to $I_{K,max,int}$ = 50 A secondary.

This results in a temporary load for the series resistor over 0.5 s of:

$$P_{0.5s} = \frac{V_{RMS,stab}^2}{R} = \frac{579.7^2}{375} = 896\ W \quad \text{at the 5-A-transformer}$$

$$P_{0.5s} = \frac{V_{RMS,stab}^2}{R} = \frac{2151.6^2}{3500} = 1322.7\ W \quad \text{at the 1-A-transformer}$$

Observe that with the selection of a higher pickup value I_{set}, the resistor value must be lowered and therefore the dissipation rises sharply.

The varistor (see following figure) must be sized such that it remains high-impedance up to the knee-point voltage, for example:

- Approx. 100 V with 5-A transformer
- Approx. 500 V with 1-A transformer

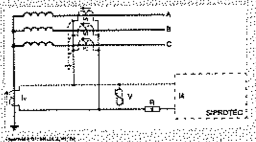

Figure 6-108 Connection Diagram of the Restricted Ground-Fault Protection According to the High-Impedance Principle

Even with unfavorable wiring, the maximum occurring voltage peaks do not exceed 2 kV for safety reasons.

When for performance reasons, several varistors must be connected in parallel, give preference to types with flat characteristic curves, in order to avoid an unbalanced load. Siemens therefore recommends the following types by METROSIL:

600A/S1/S256 (k = 450, β = 0.25)

600A/S1/S1088 (k = 900, β = 0.25)

In this example, set the pickup value of the first Definite-time overcurrent protection stage (setting Threshold) to 0.1 A for 5-A transformers or 0.05 A for 1-A transformers. No further protection stages are needed. Delete these or switch them off. Set the Operate delay setting to 0 s.

If several current transformers are connected in series, for example, with use as busbar protection with several feeders, the magnetization currents of the transformers switched in parallel can no longer be neglected. In

this case, add up the magnetization currents at half of the knee-point voltage (corresponds to the set Threshold). These magnetization currents reduce the current through the resistor R. Thus, the actual pickup value is correspondingly higher.

6.12.8 Application Example: Tank Leakage Protection

6.12.8.1 Description

Tank leakage protection records short circuits to ground – including high-impedance ones – between a phase and the tank of a transformer. The tank is thus insulated, or at least grounded with high impedance. The tank must be connected with a line to ground. The current that flows through this line is fed to the protection device. If a short-circuit to ground occurs in a tank, a fault current (tank current) flows to substation ground via the ground connection.

The function **Overcurrent protection, 1-phase** detects the tank current. If the tank current exceeds the set **Threshold**, the function **Overcurrent protection, 1-phase** generates an operate indication. Depending on the set **Operate delay**, the transformer is tripped immediately or time-delayed on all sides.

For tank protection, a sensitive, 1-phase current measuring input is used.

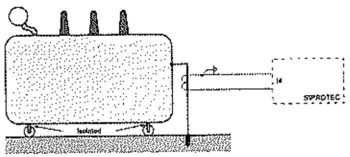

Figure 6-109 Tank-Control Principle

6.12.8.2 Application and Setting Notes

A prerequisite for the application of tank protection is the availability of a sensitive input transformer at device input I4.

If you connect **Measuring point I 1-ph** with the function group **Voltage-current 1-phase**, the function **Overcurrent protection, 1-phase** works with the 1-phase current connected to input I4.

Use only the first definite time-overcurrent protection stage of function **Overcurrent protection, 1-phase**. The **Threshold** setting is used to set the pickup value. No further protection stages are needed. Delete these or switch them off. Set the **Operate delay** setting to 0 s.

6.13 Non-Directional Intermittent Ground-Fault Protection

6.13.1 Overview of Functions

A typical characteristic of intermittent ground faults is that they often extinguish automatically and strike again after some time. The fault duration can last between a few milliseconds and many seconds. Thus, such faults are not detected at all or not selectively by the ordinary overcurrent protection. If pulse durations are extremely short, not all protection devices in a short-circuit path can pick up. Thus, selective tripping is not ensured.

Due to the time delay of the overcurrent protection function, such faults are too short to initiate switching off the faulted cable. The short-circuit protection can clear such ground faults selectively only if the ground faults have become permanent.

But such intermittent ground faults already bear the risk of damaging the equipment thermally. This is why SIPROTEC 5 devices feature a protection function that is able to detect such intermittent ground faults and accumulates their duration. If the sum reaches a configurable value within a certain time, the limit of the thermal rating has been reached. If intermittent ground faults are distributed over a long period or if the ground fault disappears and does not restrike after some time, the equipment under load is expected to cool down. Tripping is not necessary in this case.

The **Non-directional intermittent ground-fault protection** function is used to protect against intermittent ground faults which occur, for example, in cables due to poor insulation or water ingress in cable joints.

6.13.2 Structure of the Function

The **Non-directional intermittent ground-fault protection** function can be used in protection function groups with current measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously. The non-preconfigured stages are shown in gray in the following figure.

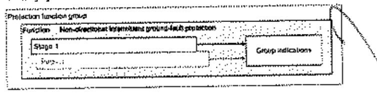

Figure 6-110 Structure/Embedding of the Function

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6.13.3 Stage Description

Logic

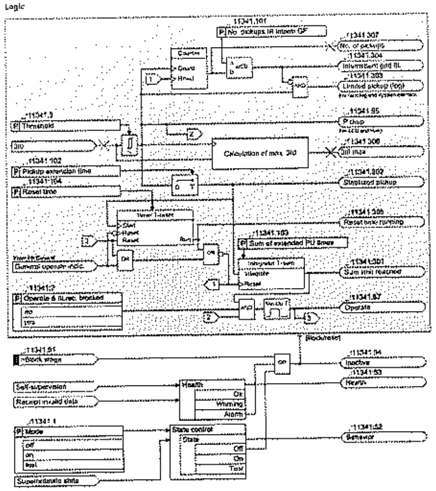

Figure 6-111 Logic of the Non-Directional Intermittent Ground-Fault Protection

Measured Value 3I0

The intermittent ground-fault current 3I0 can either be detected via the standard ground current input I_N or via the sensitive ground-current input I_{Ns}. It can also be calculated from the sum of the 3 phase currents. The measured value depends on the parameter **Connection type** of the measuring point I-3ph.

Table 6-9 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary at Irated = 1 A)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
+ IN + IN separate	Measured	4 * Protection	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
	Measured and calculated when exceeding 1.6 A	3 * Protection, 1 * sensitive	0.001 A to 35.000 A

Method of Measurement

The stage calculates the RMS value of 3I0 since this value takes into account the higher-order harmonics components and the direct component (DC). Both components contribute to the thermal load.

Maximum 3I0 of the Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault. The statistic value *3I0 max.* is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. With the outgoing operate signal, this value is logged via the information *3I0 max.*.

Pickup and Intermittent Ground-Fault Indication

When 3I0 exceeds the threshold value, the pickup signals *Pickup* and *Limited pickup (log)* are issued. The stage generates the *Stabilized pickup* signal by extending the *Pickup* for a defined time (parameter **Pickup extension time**).

The stage counts the *Pickup* signals. If the counted number reaches the configured **No. pickups till interm.GF**, the *Intermittent gnd.flt.* signal is issued. The signal *Limited pickup (log)* is not issued anymore after the issue of the *Intermittent gnd.flt.* signal.

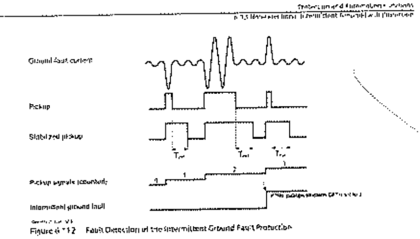

Figure 6-112 Fault Detection of the Intermittent Ground-Fault Protection

T_{v} Defined time for extending the *Pickup* signal

Number of Pickups

The stage counts the number of *Pickup* signals during the intermittent ground fault. With the operate of the stage this number is logged via the information *No. of pickups*.

Accumulation of the Intermittent Ground-Fault Current and Issuing the Operate Signal

An intermittent ground fault can result in thermal stress on the protected equipment. The magnitude and the duration of the ground-fault current are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integration value reaches the predefined **Sum of extended PU times**, the limit of the thermal load is reached. The stage issues the signal *Sum limit reached* and operates when the signal *Pickup* is active.

Reset Timer for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if ground faults extinguish and does not restrike again within a larger time, the stressed equipment can cool down. In this case, an operation is not necessary. The interval between ground faults is monitored with the reset timer. If a ground fault occurs, the Timer T-reset with its setting **Reset time** is launched simultaneously with Integrator T-sum. Unlike the integrator, each new ground fault restarts the reset timer with its initial value. If Timer T-reset expires, that is, no new ground fault was detected during that period, all memories and the stage logic are reset. Timer T-reset thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new fault event.

Reset Conditions

Under one of the following 2 conditions, Timer T-reset is reset.

- The intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, Integrator T-sum and Counter are reset and the whole stage is reset and returns to its idle state.

- Timer T-reset expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter **Operate & flt.rec. blocked** to **yes**, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start & Stop of Fault Recording, Fault Logging, and General Pickup

The *Stabilized pickup* signal initiates the fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the *Stabilized pickup* signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Signals

Intermittent ground faults may cause other functions, based on overcurrent measurement, to pick up, which may result in a burst of signals. In order to avoid an overflow of the fault log, a special mechanism is applied to the signals of these functions after detection of an intermittent ground fault (signal *Intermittent gnd.flt.*).

The special mechanism is applied for the following listed functions and other functions are not influenced:

- Overcurrent protection, phases
- Overcurrent protection, ground
- Directional overcurrent protection, phases
- Directional overcurrent protection, ground
- Overcurrent protection, 1 phase
- Negative sequence protection with definite-time characteristic curve
- Directional negative-sequence protection with definite-time delay
- Directional overcurrent-protection stage with cos phi or sin phi measurement
- Directional overcurrent-protection stage with 3I0-phi (V,I) measurement
- Sensitive ground-current protection with 3I0

If a function picks up, normally its output signals are sent directly to the information targets, for example, the pickup signal is written to the fault log. To avoid overflow of logs due to intermittent ground faults, a special log buffer mechanism is used. If one of the preceding functions or stages picks up after an intermittent ground fault has been detected (signal *Intermittent gnd.flt.* has been issued), its output signals are processed as shown in the following 2 tables.

Table 6-10 Processing of the Signal Status Changes

Processing of Signal Status Changes	Description
Special buffering mechanism	The status changes of signals are written to a special buffer. This buffer can store a maximum of 2 status changes (the most recent ones) for each signal. With the pickup signal as example, if one of the preceding protection functions or stages picks up during an active *Intermittent gnd.flt.* signal, the pickup signal is not written in the fault log anymore unless one of the preceding functions operates. After the operation, the buffered signals are written to the information target with the original time stamp. This measure ensures that a pickup signal, although delayed, is always signaled in association with each operate command.
Discard	The signal status changes are discarded.
Pass through	The signal is forwarded to the information target without restriction. Special buffering does not apply for specific information targets as protection measure, for example, reverse interlocking, need these signals for proper operation.

Table 6-11 Information Target with Different Processing of Signal Status Changes

Information Target		Processing of Signal Status Changes
Processing of Signal Status Changes	Operational log Fault log Ground-fault log User defined log	Special buffering mechanism
Communication interface	IEC 61850-8-1 Client/Server IEC 60870-5-103/104 DNP V3.0	Special buffering mechanism
Protection interface	PDI	Pass through
IEC 61850-8-1 GOOSE		Pass through
CFC		Pass through
LEDs		Pass through
Binary output		Pass through
Fault recorder		Pass through
Automatic reclosing function		Discard
Circuit breaker failure protection		Discard
Group indications		Discard

6.13.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults as the protection function only operates after repeated detection of a fault or after the integration value reaches the predefined **Sum of extended PU times**. Besides this, its basic design is to prevent thermal overload. For these reasons, the intermittent ground-fault protection function is not intended to start the automatic reclosing function.

Routing of Pickup Signals

The signal *Pickup* is supposed to be routed to LED and relay. The signal *Limited pickup (log)* is only reported to the fault log and communication interface before the signal *Intermittent gnd.flt.* is issued. This scheme prevents a burst of messages.

> **NOTE**
>
> To avoid a burst of messages, do not route the signal *Pickup* to the operational log and fault log.

Parameter: 3I0 Threshold

- Default setting (_:11341:3) **Threshold** = 1.00 A

With the **Threshold** parameter, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground fault current increases.

Parameter: No. pickups till interm.GF

- Default setting (_:11341:101) **No. pickups till interm.GF** = 3

With the parameter **No. pickups till interm.GF**, you set the number of counted *Pickup* signals after which the ground fault is considered as intermittent.

Parameter: Pickup extension time

- Default setting (_:11341:102) **Pickup extension time** = 0.10 s

You can get a stabilized pickup signal with the **Pickup extension time** parameter. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: Sum of extended PU times

- Default setting (_:11341:103) **Sum of extended PU times** = 20 s

With the **Sum of extended PU times** parameter, you set the threshold value for the integrator. If the integration reaches **Sum of extended PU times**, the stage operates if the pickup state is present.

This **Sum of extended PU times** represents one of the 4 selectivity criteria (pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on adjacent feeders. It is comparable to the time grading of the overcurrent protection. The protection in the radial system which is closest to the intermittent fault and picks up, has the shortest summation time **Sum of extended PU times**.

Parameter: Reset time

- Default setting (_:11341:104) **Reset time** = 300 s

With the parameter **Reset time**, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the **Reset time**, the counter and integrator are reset.

The **Reset time** parameter must be much higher than the operate value of the **Sum of extended PU times**.

Parameter: Operate & flt.rec. blocked

- Default setting (_:11341:2) **Operate & flt.rec. blocked** = no

You can block the operate indication, the fault recording, and the fault log with the **Operate & flt.rec. blocked** parameter. In this case, a ground-fault log is created instead of the fault log.

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EXAMPLE

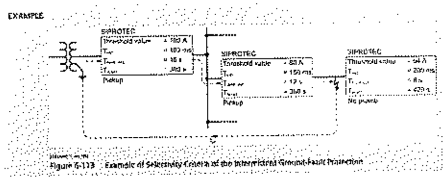

Figure 6-113 Example of Selectivity Criteria of the Intermittent Ground-Fault Protection

6.13.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:11341:1	Stage 1:Mode		• off • on • test	off
_:11341:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:11341:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:11341:101	Stage 1:No. pickups till interm.GF		2 to 10	3
_:11341:102	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:11341:103	Stage 1:Sum of extended PU times		0.00 s to 100.00 s	20.00 s
_:11341:104	Stage 1:Reset time		1.00 s to 600.00 s	300.00 s

6.13.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:11341:81	Stage 1:>Block stage	SPS	I
_:11341:54	Stage 1:Inactive	SPS	O
_:11341:52	Stage 1:Behavior	ENS	O

No.	Information	Data Class (Type)	Type
_:11341:53	Stage 1:Health	ENS	O
_:11341:55	Stage 1:Pickup	ACD	O
_:11341:302	Stage 1:Stabilized pickup	ACD	O
_:11341:303	Stage 1:Limited pickup (log)	ACD	O
_:11341:304	Stage 1:Intermittent gnd flt.	SPS	O
_:11341:301	Stage 1:Sum limit reached	SPS	O
_:11341:305	Stage 1:Reset time running	SPS	O
_:11341:57	Stage 1:Operate	ACT	O
_:11341:306	Stage 1:3I0 max.	MV	O
_:11341:307	Stage 1:No. of pickups	MV	O

6.14 Directional Intermittent Ground-Fault Protection

6.14.1 Overview of Functions

The function Directional intermittent ground-fault protection:

- Detects the intermittent ground faults in grounded, compensated, or isolated cable systems selectively
- Can be operated in 2 different modes:
  - Operate only by counting directional ground-current pulses
  - Operate by integration of the fault current in combination with a directional criterion by counting directional ground-current pulses

The intermittent ground faults in cable systems are frequently caused by weak insulation or water ingress in cable joints. The ground faults are characterized by the following properties:

- Intermittent ground faults show very short high ground-current pulses (up to several hundred amperes) with a duration of less than 1 ms.
- Intermittent ground faults are self-extinguishing and reignite within one half period up to several periods, depending on the power-system conditions and the fault type.
- Intermittent ground faults can persist over longer periods (several seconds to minutes) and develop to static ground faults.

6.14.2 Structure of the Function

The function Directional intermittent ground-fault protection can be used in protection function groups with current and voltage measurement. The function is preconfigured by the manufacturer with 1 stage, and a maximum of 2 stages can be operated simultaneously.

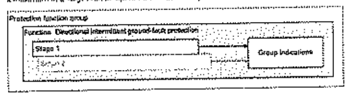

Figure 6-114 Structural Embedding of the Function

6.14.3 Stage Description

Overview

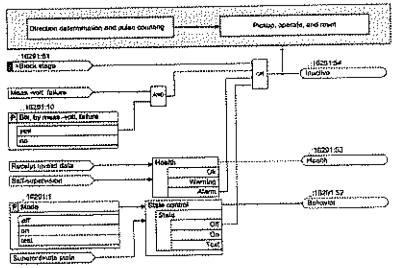

Figure 6-115 Logic of the Directional Intermittent Ground Fault Protection

Blocking of the Stage with Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

- From an internal source upon pickup of the Measuring-voltage failure detection function
- From an external source via the binary-input signal >Open of the function block Volt.-trans. c. b., which links in the tripping of the voltage-transformer circuit breaker

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

Logic for Direction Determination and Pulse Counting

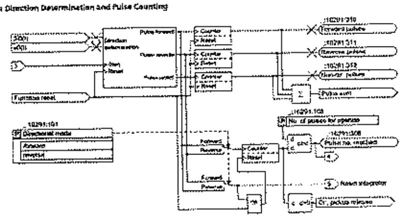

Figure 6-116 Logic Diagram of Direction Determination and Pulse Counting

(1) The input signal 3 is from Figure 6-117.

Measurement Values for Direction Determination

The function Directional intermittent ground-fault protection uses the zero-sequence active energy to determine the direction of the ground current pulse.

The zero-sequence active energy is calculated from v0(t) and 3i0(t). The zero-sequence voltage v0(t) can either be measured via the voltage input VN or can be calculated from the sum of 3 phase-to-ground voltages. The measured value depends on the parameter Connection type of the measuring point V-3ph.

The intermittent ground-fault current 3i0(t) can either be measured via the ground-current input IN or via the sensitive ground-current input INS. It can also be calculated from the sum of the 3 phase currents. The measured value and its setting range depend on the parameter Connection type of the measuring point I-3ph.

Table 6-12 Threshold Setting Range with Different Connection Types

Connection Type of the Measuring Point I-3ph	Ground Current	CT Terminal Type	Threshold Setting Range (Secondary at Irated = 1 A)
3-phase	Calculated	4 * Protection	0.030 A to 35.000 A
		3 * Protection, 1 * sensitive	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
x + IN x + IN separate	Measured	4 * Protection	0.030 A to 35.000 A
		4 * Measurement	0.001 A to 1.600 A
	Measured and calculated when exceeding 1.6 A	3 * Protection, 1 * sensitive	0.001 A to 35.000 A

Direction Determination and Pulse Counting

When the RMS value of 3I0 exceeds the set threshold value (signal no. 3 in Figure 6-116), the direction determination process is started and is continuously carried out until the function resets. At first, the current pulse (current peak) detection takes place. If a current pulse is detected, the direction determination for this pulse is carried out.

The direction is determined by calculating the active zero-sequence energy of the current pulse. The active zero-sequence energy of the pulse is compared to internal threshold values resulting in the directional decision forward, reverse, or non-directional. During the ongoing intermittent ground fault, the directional results for all current pulses are counted.

Directional Mode and Directional Pulse Counter Criterion

The parameter Directional mode defines whether the function operates in forward or in reverse direction. The pulses in the specified direction are counted. If the pulse counter reaches the threshold value set in the parameter No. of pulses for operate, the signal Pulse no. reached is issued. Depending on the operating mode (Counter or Integrator and counter) of the function, the signal can immediately cause the operate of the function (Counter mode) or it is processed as directional release criteria (Integrator and counter operating mode). Refer to the further description in the following sections.

The directional pulse counter is reset when a different direction than the set Directional mode is detected. An undefined direction result does not reset the counter.

Operating Mode

2 different functional operating modes are available: Counter and Integrator and counter. You can select the different operating modes using the parameter Operating mode.

- Operating mode Counter:
  Many ground-current pulses of intermittent ground faults can result in a damage of the protected object. In this mode, the criterion for operate is only the number of directional current pulses. This is similar to the SIPROTEC 4 implementation.
- Operating mode Integrator and counter:
  An intermittent ground fault can result in thermal stress on the protected object. The magnitude and the duration of the ground current pulses are decisive for the thermal stress. In order to calculate the thermal stress, the stage sums up the duration of the stabilized pickups with an integrator. If the integration value reaches the threshold value, one criterion for the operate is fulfilled. The 2nd criterion for the operate is the ground fault direction. The ground-fault direction is determined by counting the directional ground current pulses.

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Pickup, Operate, and Reset Logic for the Counter Mode

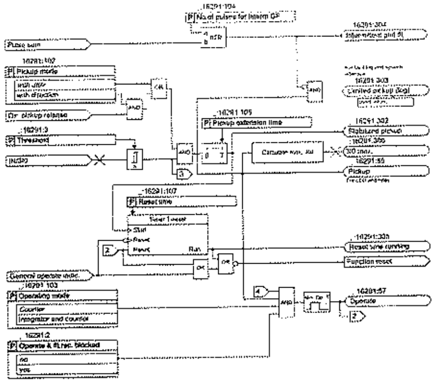

Figure 6-117 Pickup, Operate, and Reset Logic in Operating Mode Counter

(1) The internal signal 4 is from Figure 6-116.

Pickup, Operate, and Reset Logic for the Integrator and Counter Mode

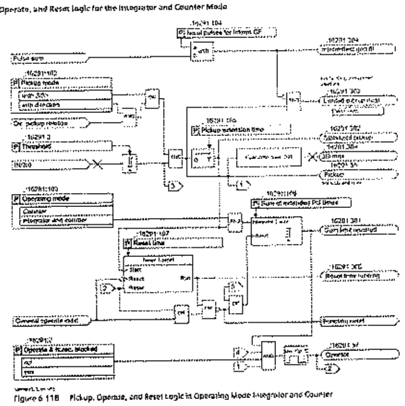

Figure 6-118 Pickup, Operate, and Reset Logic in Operating Mode Integrator and Counter

(1) The internal signal 4 and 5 are from Figure 6-116.

Measurement Value for Pickup and Integration

The stage calculates the RMS value of 3I0 since this value takes into account the higher order harmonic components and the direct component (DC). Both components contribute to the thermal load.

Pickup, Limited Pickup, and Stabilized Pickup

Whenever 3I0 exceeds Threshold, the stage issues the signal *Pickup*. The signal is intended to be applied for LED and relay output.

Stabilized pickup is formed by prolonging the pickup indication by a settable time Pickup extension time. This stabilization is especially important for the coordination with the existing static or electromechanical overcurrent protection.

The *Limited pickup (log)* signal is intended to be applied for logging and communication interface. The *Limited pickup (log)* signal will be entered in the fault log and reported via the system interface unless the *Intermittent gnd. flt.* indication is given. This behavior prevents a burst of indications.

Intermittent Ground Fault Indication

The stage counts the 3I0 pulses. If the sum of forward pulse counts, reverse counts, and directional undefined counts is equal to or greater than No. of pulses for interm.GF, the signal *Intermittent gnd. flt.* is issued.

If the signal *Intermittent gnd. flt.* is issued, the pickup indications of some protection functions will be restrained to avoid an indication burst during an intermittent ground fault.

Operate

The conditions for issuing the signal *Operate* depend on the operating mode.

Operating Mode	Conditions for Issuing the Operate Signal
Counter	• The current pulse counter reached the No. of pulses for operate, which is signaled via the *Pulse no. reached* indication. • The pickup is active, which is signaled via the *Pickup* indication.
Integrator and counter	• The 3I0 current integration value reaches the predefined Sum of extended PU times, which is signaled via the *Sum limit reached* indication. • The current-pulse counter reached the No. of pulses for operate, which is signaled via the *Pulse no. reached* indication. • The pickup is active, which is signaled via the *Pickup* indication.

When an opposite current pulse against the setting Directional mode is detected, the **Integrator T-sum** and the **Counter** are reset.

Reset Time for the Definition of the Interval between Independent Ground Faults

If there is a large interval between independent ground faults or if the ground fault extinguishes and does not restrike again within a larger time, the stressed equipment can cool down. In this case, no operate is necessary. The interval between ground faults is monitored with the reset time. If a ground fault occurs, the **Timer T-reset** with the setting **Reset time** and the **Integrator T-sum** are launched simultaneously. Unlike the integrator, each new ground current pulse restarts the reset time with its initial value. If the **Timer T-reset** expires, that is, no new ground fault was detected during that period, all memories and the stage logics are reset. The **Timer T-reset** thus determines the time during which the next ground fault must occur to be processed yet as intermittent ground fault in connection with the previous fault. A ground fault that occurs later is considered as a new ground-fault event.

Reset Conditions

Under one of the following 2 conditions, **Timer T-reset** is reset:

- The intermittent ground-fault protection stage operates.
- The general operate indication is going.

Under one of the following conditions, **Integrator T-sum** and **Counter** are reset and the whole stage is reset and returns to its idle state:

- The **Timer T-reset** expires without an operate signal of this stage or another function was issued.
- The operate signal of the intermittent ground-fault protection stage is going.
- The general operate indication is going without the operate signal of the intermittent ground-fault protection stage issued.

Maximum Value 3I0 of the Ground Fault

The stage records the maximum RMS value of 3I0 during the intermittent ground fault. The statistic value *3I0 max.* is a percentage value calculated through dividing the primary maximum RMS value by the rated current value of the protected object. If the function resets or operates, this value is logged via the signal *3I0 max.*.

Fault Log and Fault Recording

You can select between the ground-fault log without fault recording or the normal fault log with fault recording. If you set the parameter Operate & flt.rec. blocked to yes, the operate of the stage and fault recording are blocked and the information automatically appears in the ground-fault log. Otherwise, the operate and fault recording are not blocked and the information appears in the normal fault log.

Start and Stop of Fault Recording, Fault Logging, and General Pickup

The *Stabilized pickup* signal initiates fault recording, fault logging, and the general pickup of the function group. The fault recording starts according to the pre-trigger time before the *Stabilized pickup* signal rises.

With the reset condition of this stage, the fault recording, fault logging, and the general pickup of the function group are terminated.

Influence on Other Functions to Avoid a Burst of Indications

In this case, the function uses the same mechanism as the Non-directional intermittent ground-fault protection. For more information, refer to chapter *Influence on Other Functions to Avoid a Burst of Signals*, Page 538.

6.14.4 Application and Setting Notes

No Start of the Automatic Reclosing Function

Automatic reclosing is not an effective measure against intermittent ground faults. For this reason, the Directional intermittent ground-fault protection function is not intended to start the Automatic reclosing function.

Routing of Pickup Signals

The signal *Pickup* is supposed to be routed to an LED and a relay. The signal *Limited pickup (log)* is only reported to the fault log and communication interface until the signal *Intermittent gnd. flt.* is issued. This scheme prevents a burst of indications.

> **NOTE**
> To avoid a burst of indications, do not route the signal *Pickup* to the operational log and to the fault log.

Parameter: Threshold

- Default setting (_:16291:3) Threshold = 1.00 A

With the parameter Threshold, you set the threshold value of the ground current 3I0, measured as RMS value.

A rather sensitive setting is possible to respond also to short ground faults since the pickup time shortens as the ground-fault current increases.

Parameter: Directional mode

- Default setting (_:16291:101) Directional mode = forward

With the parameter Directional mode, you define if the function operates in forward or in reverse direction.

Parameter: Pickup mode

- Default setting (_:16291:102) Pickup mode = with 3I0>

With the parameter Pickup mode, you define under which conditions pickup is detected and fault logging and recording start:

- When the parameter Pickup mode is set to with 3I0>, the signal *Pickup* is released without considering the ground fault direction. The signal *Pickup* is issued once the INI3I0 exceeds the threshold value.
- When the parameter Pickup mode is set to with direction, the signal *Pickup* is issued when at least one pulse direction is the same as the direction specified by the set value of parameter Directional mode.

Parameter: Operating mode

- Default setting (_:16291:103) Operating mode = Counter

With the parameter Operating mode, you define if the function operates in Counter or in Integrator and counter mode.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. This is a simple method which is similar to the implementation in the 7SJ SIPROTEC 4 devices. Siemens recommends using this method if no time grading or only simple time grading between protection devices (time grading of only 2 or 3 devices) is required. Time grading is then carried out by increasing the parameter value No. of pulses for operate towards the infeed.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The integrator works in the same way as for the non-directional intermittent ground fault function. This allows the same time-grading principles as for the non-directional intermittent ground fault function. Refer to this function for more description.

Parameter: No.of pulses for interm.GF

- Default setting (_:16291:104) No.of pulses for interm.GF = 3

With the parameter No.of pulses for interm.GF, you set the total number of pulse counts (*forward*, *reverse* and *non-dir. pulses*) at which the ground fault is considered to be intermittent. Siemens recommends using the default setting.

Parameter: Pickup extension time

- Default setting (_:16291:105) Pickup extension time = 0.10 s

With the parameter Pickup extension time, you get a prolonged and thus stabilized pickup signal. This stabilization is especially important for the coordination with existing static or electromechanical overcurrent protections.

Parameter: No. of pulses for operate

- Default setting (_:16291:108) No. of pulses for operate = 5

The pulses in the specified direction from Directional mode are counted. If the pulse counter reaches the set value of the parameter No. of pulses for operate, the directional counter criterion is fulfilled.

The setting of parameter No. of pulses for operate depends on the Operating mode.

Operating Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. Thus do not set the value for parameter No. of pulses for operate too small. Consider that a permanent intermittent ground fault will cause many current pulses. If no time-grading considerations are required, Siemens recommends using a value in the range of 10 to 20.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The value for parameter No. of pulses for operate to fulfil the directional criterion can be set to a rather small value in the range of 3 to 5.

Parameter: Sum of extended PU times

- Default setting (_:16291:106) Sum of extended PU times = 20.00 s

This parameter is only relevant in the operating mode Integrator and counter.

With the parameter Sum of extended PU times, you set the threshold value for the integrator. If the integration reaches Sum of extended PU times, the stage operates if the *Pulse no. reached* signal and the pickup state is present.

The parameter Sum of extended PU times represents one of the 5 selectivity criteria (ground-fault direction, pickup threshold, pickup extension time, reset time, and integrator threshold value) for coordination of the relays on subordinate devices. It is comparable to the time grading of the overcurrent protection.

The Sum of extended PU times has the shortest summation time in the radial system for the device that is closest to the intermittent ground fault and that picks up.

Parameter: Reset time

- Default setting (_:16291:107) Reset time = 300 s

With the parameter Reset time, you can define the maximum interval between 2 adjacent ground faults. If the interval is larger than the Reset time, the counter and integrator are reset.

The Reset time parameter must be much higher than the operate value of the Sum of extended PU times.

Parameter: Operate & flt.rec. blocked

- Default setting (_:16291:2) Operate & flt.rec. blocked = no

With the parameter Operate & flt.rec. blocked, you can block the operate indication, the fault recording, and the fault log. In this case, a ground-fault log is created instead of the fault log.

6.14.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:16291:1	Stage 1:Mode		• off • on • test	off
_:16291:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:16291:10	Stage 1:Blk. by meas.-volt. failure		• no • yes	yes
_:16291:101	Stage 1:Directional mode		• forward • reverse	forward

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Addr.	Parameter	C	Setting Options	Default Setting
_:16291:102	Stage 1:Pickup mode		• with 3I0> • with direction	with 3I0>
_:16291:103	Stage 1:Operating mode		• Counter • Integrator and counter	Counter
_:16291:3	Stage 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:16291:105	Stage 1:Pickup extension time		0.00 s to 10.00 s	0.10 s
_:16291:104	Stage 1:No.of pulses for interm.GF		2 to 10	3
_:16291:106	Stage 1:Sum of extended PU times		0.00 s to 100.00 s	20.00 s
_:16291:107	Stage 1:Reset time		1.00 s to 600.00 s	300.00 s
_:16291:108	Stage 1:No. of pulses for operate		2 to 100	5

6.14.6 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:16291:81	Stage 1:>Block stage	SPS	I
_:16291:54	Stage 1:Inactive	SPS	O
_:16291:52	Stage 1:Behavior	ENS	O
_:16291:53	Stage 1:Health	ENS	O
_:16291:55	Stage 1:Pickup	ACD	O
_:16291:302	Stage 1:Stabilized pickup	ACD	O
_:16291:303	Stage 1:Limited pickup (log)	ACD	O
_:16291:304	Stage 1:Intermittent gnd.flt.	SPS	O
_:16291:301	Stage 1:Sum limit reached	SPS	O
_:16291:308	Stage 1:Pulse no. reached	SPS	O
_:16291:305	Stage 1:Reset time running	SPS	O
_:16291:57	Stage 1:Operate	ACT	O
_:16291:306	Stage 1:3I0 max.	MV	O
_:16291:310	Stage 1:Forward pulses	MV	O
_:16291:311	Stage 1:Reverse pulses	MV	O
_:16291:312	Stage 1:Non-dir. pulses	MV	O

6.15 Sensitive Ground-Fault Detection

6.15.1 Overview of Functions

2 functions are available for ground-fault detection: A directional one that is used if, in addition to the zero-sequence current 3I0, the zero-sequence voltage V0 is also available, and a non-directional one that is used if only the zero-sequence current 3I0 is available.

The **Directional sensitive ground-fault detection** (ANSI 67Ns) serves:

- For directional detection of permanent ground faults in isolated or resonant-grounded systems
- For directional detection of fast extinguishing transient ground faults in isolated or resonant-grounded systems
- For determination of the faulty phase
- For detection of high-resistance ground faults in effectively (solidly) or low resistance (semi solidly) grounded systems

The **Non-directional sensitive ground-fault detection** (ANSI 51Ns) serves:

- For ground-fault detection in isolated or resonant-grounded systems
- For detection of high resistance ground faults in effectively (solidly) or low resistance (semi solidly) grounded systems

6.15.2 Structure of the Function

Directional Sensitive Ground-Fault Detection

The **Directional sensitive ground-fault detection** function can be used in protection function groups that make current and voltage zero-sequence systems (3I0 and V0) available. The function is preconfigured at the factory with a **V0> stage, a directional 3I0> stage with cos φ or sin φ measurement, and a transient ground-fault stage.**

The following stages can be operated simultaneously within the function:

- **2 V0> stages with determination of the faulty phase**
- **4 directional 3I0> stages with cos φ or sin φ measurement**
- **2 directional transient ground-fault stages**
- **4 directional 3I0> stages with φ(V0, 3I0) measurement**
- **4 directional Y0> stages with G0 or B0 measurement** (admittance method)
- **4 non-directional 3I0> stages**
- **2 non-directional Y0> stages**

The general functionality works across stages on the function level.

The group-indications output logic generates the following group indications of the entire function by the logical OR from the stage selective indications:

- Pickup
- Operate indication

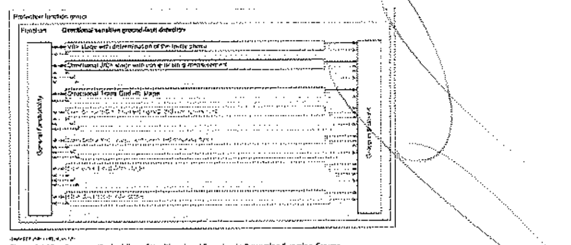

Figure 6-119 Structure/Embedding of the Directional Function in Protection Function Groups

Non-Directional Sensitive Ground-Fault Detection

The **Non-directional sensitive ground-fault detection** function can be used in protection function groups that only make the zero sequence system (3I0) available. The function is preconfigured at the factory with a **non-directional 3I0> stage.**

4 non-directional 3I0> stages and 2 non directional Y0> stages can be operated simultaneously in the function.

The general functionality works across stages on the function level.

The group indications output logic generates the following group indications of the entire function by the logical OR from the stage-selective indications:

- Pickup
- Operate indication

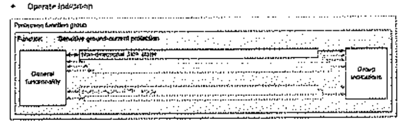

Figure 6-120 Structure/Embedding of the Non-Directional Function in Protection Function Groups

6.15.3 General Functionality

6.15.3.1 Description

Logic

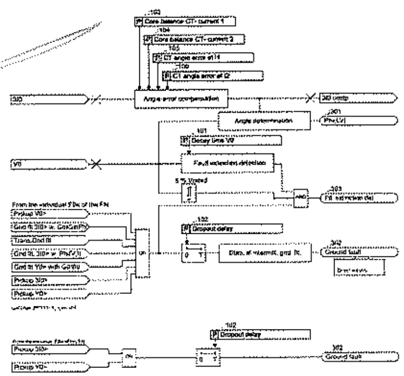

Figure 6-121 Logic Diagram of the Cross-Stage Functionality of the Non-Directional Function

Operational Measured Value φ(I,V)

The function block calculates the angle between IN and V0 and makes the angle available as function measured value Phi(I,V).

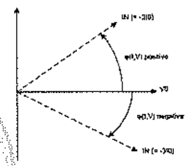

Figure 6-122 Sign Definition for the Measured Value

Fault-Extinction Detection

The extinction of the fault is characterized by the fact that the zero sequence voltage subsides. Depending on the system conditions and fault characteristics, this process can last several 100 ms. If a continuously fading zero-sequence voltage is detected during the set time Decay time V0, then the fault is considered extinguished. The signal *Flt. extinction det.* is issued.

Thus, the possibility exists, for example, to block the 3I0> stage with cos φ or sin φ measurement directly after the fault extinction, in order to avoid an overfunction during the subsiding process with a very sensitive setting of the stage.

Angle-Error Compensation

The high reactive power factor in the arc suppression-coil ground system and the unavoidable air gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. Using the characteristic shown in the following figure, the device approaches the angle error of the core balance current transformer with sufficient precision.

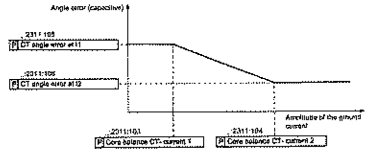

Figure 6-123 Correction of the Transmission Characteristic Curve of a Core Balance Current Transformer

Ground-Fault Indication, Stabilization at Intermittent Ground Fault

The indication *(_:302) Ground fault* indicates the ground fault and manages the ground-fault log (see Ground-Fault Log, Page 558). The corresponding information of the stages used is accessed for the generation of the indication.

The indication *Ground fault* contains the direction information, independent of the parameterized working direction of a stage. The indication is thus suited for transfer to a station.

To avoid a flood of indications in case of an intermittent ground fault, a maximum of 30 status changes of this indication is logged per ground fault. An intermittent ground fault must be treated as a ground fault so that the stabilization can take action. This is ensured with the parameter Dropout delay, by the dropout of the indication *Ground fault* being delayed. If the next ignition of the ground fault takes place during the dropout delay, the indication does not dropout and the log remains open.

> **NOTE**
>
> The *Ground fault* indication in the general stage must be routed to the ground-fault log. If not, you can meet an overflow of the ground-fault log when an intermittent ground fault occurs.

Ground-Fault Log

Ground faults can be recorded in a designated buffer, the ground-fault log. As long as the Operate & flt.rec. blocked parameter is set to yes, all indications routed into the ground-fault log are written in the ground-fault log.

The criterion for opening the ground-fault log is the raising of any indication which is routed to the ground-fault log, for example, the indication *Ground fault*. The criterion for closing is the clearing of all routed indications.

Related Topics

You can find general notes on the ground-fault log in chapter Indications under [illegible] Ground Fault Log.

Value Indications

If the following value indications can be calculated, they are written into the log (ground fault log or fault log) at the time of the 1st raising ground-fault indication and the 1st operate indication of any stage.

- 3I0 (value)
- 3I0 active component
- 3I0 reactive component
- V0
- φ (IN, V0)

6.15.3.2 Application and Setting Notes

Indication: Ground fault

To indicate the ground fault and its direction via the protocol, Siemens recommends using the indication *(_:302) Ground fault*. The indication contains the direction information, independent of the parameterized working direction of a stage. And this indication is also stabilized against a flood of indications in case of an intermittent ground fault.

Parameter: Decay time V0

- Recommended setting value (_:101) Decay time V0 = 0.10 s

With the Decay time V0 parameter, you specify the time slot for the detection of a fault extinction. If V0 continuously falls within this time, fault extinction is detected and the indication *Flt. extinction det.* is issued.

Siemens recommends using the default setting.

Parameter: Dropout delay

- Recommended setting value (_:102) Dropout delay = 1.00 s

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To avoid chattering of the indication *Ground fault* during an intermittent ground fault and thus a frequent opening and closing of the ground-fault log, the dropout of the indication *Ground fault* (and thus the closing of the log) can be delayed by the Dropout delay.

Siemens recommends using the default setting.

Using the default setting ensures that no flood of indications arises in case of an intermittent ground fault for the indication *Ground fault*. The intermittent ground fault is then treated as a ground fault, and the stabilization of the indication *Ground fault* can thus take action.

Angle-Error Compensation of the Core Balance Current Transformer

- Default setting (_:103) Core balance CT- current 1 = 0.050 A
- Default setting (_:104) Core balance CT- current 2 = 1.000 A
- Default setting (_:105) CT angle error at I1 = 0.0°
- Default setting (_:106) CT angle error at I2 = 0.0°

The high reactive-power factor in the arc-suppression coil-ground system and the unavoidable air gap of the core balance current transformer often make necessary a compensation of the angle error of the core balance current transformer. For the burden actually connected, the maximum angle error CT angle error at I1 and the corresponding secondary current Core balance CT- current 1 as well as a further operating point CT angle error at I2/Core balance CT- current 2 are entered from which point the angle error no longer changes appreciably.

In the isolated or grounded system, angle compensation is not necessary.

6.15.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:101	General:Decay time V0		0.06 s to 0.20 s	0.10 s
_:102	General:Dropout delay		0.00 s to 60.00 s	1.00 s
_:103	General:Core balance CT- current 1	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:104	General:Core balance CT- current 2	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:105	General:CT angle error at I1		0.0 ° to 5.0 °	0.0 °
_:106	General:CT angle error at I2		0.0 ° to 5.0 °	0.0 °

6.15.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:302	General:Ground fault	ACD	O
_:303	General:Flt. extinction det.	SPS	O

No.	Information	Data Class (Type)	Type
_:301	General:Hit. measuring window	SPS	O
_:301	General:Fault(V)	MV	O

6.15.4 Directional 3I0 Stage with Cos φ or Sin φ Measurement

6.15.4.1 Description

Logic

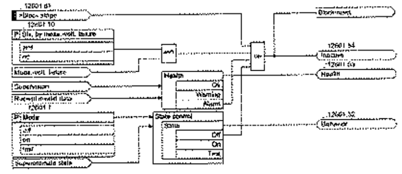

Figure 6-124 Logic Diagram of the Stage Control

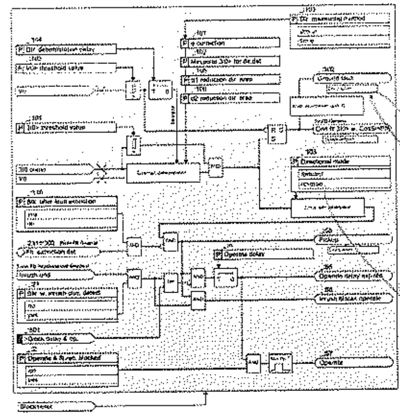

Figure 6-125 Logic Diagram of the Directional 3I0 Stage with Cos φ or Sin φ Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages V_A, V_B, and V_C using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

Depending on the setting of the parameter Connection type of the measuring point I-3ph as well as the current terminal block used, the following different linearity and settings ranges result in addition to the usual application:

Setting Value Connection Type of the Measuring Point I-3ph	3I0	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [16]
3-phase + IN separate [1] 3-phase + IN	Measured	3 x protection, 1 x sensitive	0.001 A to 35.000 A
		4 x protection	0.030 A to 35.000 A
		4 x measurement	0.001 A to 1.600 A
3-phase	Calculated	4 x protection	0.030 A to 35.000 A
		3 x protection, 1 x sensitive	0.030 A to 35.000 A
		4 x measurement	0.001 A to 1.600 A

With the use of the function within a 1-phase function group and therefore at a 1-phase measuring point I-1ph, the following different linearity and settings ranges result:

Measuring Point I-1ph	3I0	Current Terminal Block	3I0 Threshold Value Settings Range (Secondary) [17]
	Measured	Sensitive	0.001 A to 1.600 A
		Protection	0.030 A to 35.000 A

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (leakage) current.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 exceeds the threshold value 3I0> threshold value and the absolute value of the zero-sequence voltage V0 exceeds the threshold value V0> threshold value, the stage recognizes the ground fault. The direction determination (see the next paragraph) is started when the V0 threshold value is exceeded. The direction result is indicated via the *Ground fault* signal (in the general function block). If the direction result equals the parameterized direction (parameter Directional mode), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands. The result from the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its threshold value.

The following figure shows an example of the direction determination in the complex phasor diagram for the cos φ direction measurement method with a correction value of the direction straight lines from 0 (parameter φ correction). The example is suitable for the determination of the ground-fault direction in an arc-suppression-coil-ground system where the variable 3I0 · cos φ is decisive for the direction determination.

[16] These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.
[1] Usual application
[17] These values apply for a secondary rated current of 1 A. The values need to be multiplied by 5 when the secondary rated current is 5 A.

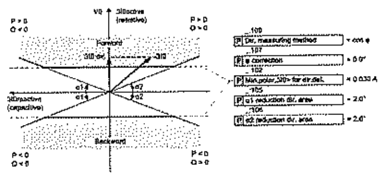

Figure 6-126 Direction-Characteristic Curve with Cos φ Measurement

The zero-sequence voltage V0 is basically the reference value for the real axis. The axis of symmetry of the direction characteristic curve coincides with the 3I0react axis for this example. For the direction determination, basically the portion of the current vertical to the set direction-characteristic curve (= axis of symmetry) is decisive (3I0 dir.). In this example, this is the active portion 3I0active of the current 3I0. The current 3I0dir. (here = 3I0active) is calculated and compared with the setting value Min.polar. 3I0> for dir.det.. If the current 3I0 dir. exceeds the positive setting value, the direction is forward. If the current 3I0 dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the α1 reduction dir. area and α2 reduction dir. area parameters, you can limit the forward and backward ranges as shown in the figure. With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle (φ correction parameter) in a range of ±45. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a rotation of +45°.

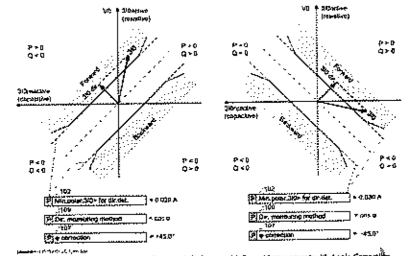

Figure 6-127 Turning the Direction-Characteristic Curves with Cos φ Measurement with Angle Correction

If you set the Dir. measuring method parameter to sin φ and the φ correction parameter to 0, the symmetry axis of the direction-characteristic curve coincides with the 3I0active axis and the V0 axis. Since the portion of the current vertical to the direction-characteristic curve (= axis of symmetry) is decisive (3I0dir.), here, the current 3I0react is included in the direction determination. If the current 3I0dir. (here, =3I0react) exceeds the negative setting value Min.polar.3I0> for dir.det., the direction is forward. If the current 3I0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement thus is appropriate for the determination of ground fault direction in isolated systems.

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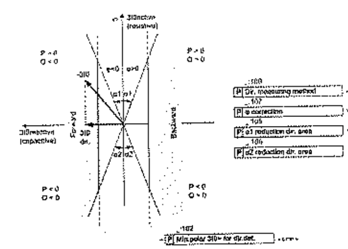

Figure 6-128 Direction-Characteristic Curve with 3I0 φ Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal >Open of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker

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

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the Blk. after fault extinction parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.4.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

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

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

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

- The device-internal supervision function **Measuring-voltage failure detection** is configured and enabled.
- The binary input signal >Open of the function block **Voltage transformer circuit breaker** is linked with the voltage transformer circuit breaker.

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

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value (_:27) Blk. w. inrush curr. detect. = no

With the Blk. w. inrush curr. detect. parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by an enabling procedure.

Parameter: Blk. after fault extinction

- Recommended setting value (_:110) Blk. after fault extinction = yes

If the Blk. after fault extinction parameter is set to yes, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: Directional mode

- Default setting (_:108) Directional mode = forward

When a fault is detected, the selection of the parameter Directional mode defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: Dir. measuring method, φ correction, Min.polar.3I0> for dir.det., 3I0> threshold value

- Default setting (_:109) Dir. measuring method = cos φ
- Default setting (_:107) φ correction = 0.0°
- Default setting (_:102) Min.polar.3I0> for dir.det. = 0.030 A
- Default setting (_:101) 3I0> threshold value = 0.030 A

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral point treatment of the system.

Note that, for the direction determination, basically only a portion of the current vertical to the set direction-characteristic curve (3I0dir.) is decisive, refer to 6.15.4.1 Description. This portion of the current is compared to the threshold value Min.polar.3I0> for dir.det.. In contrast, the absolute value of the current 3I0 is compared with the 3I0> threshold value parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt leakage current 3I0 · cos φ of the arc suppression coil is decisive for the direction determination. To evaluate the watt leakage current, set the parameters as follows: • Dir. measuring method = cos φ • φ correction = 0.0° The direction determination for a ground fault is made more difficult in that a much larger capacitive or inductive reactive current is superimposed on the small watt leakage current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the Min.polar.3I0> for dir.det. parameter, the rule of thumb is: Set the pickup value only to half of the expected measuring current as only the watt leakage current can be put into use. The 3I0> threshold value parameter can also be set to half of the expected measuring current, whereby here the entire zero-sequence current can be put to use.
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • Dir. measuring method = sin φ • φ correction = 0.0° In an isolated system, the capacitive ground-fault currents of the entire electrically connected system flow through the measuring point in case of a ground fault. The ground current of the faulty feeder is compensated in the measuring point. As the pickup value of the Min.polar.3I0> for dir.det. and 3I0> threshold value parameters, select about half of this capacitive ground fault current flowing via the measuring point.

System Type/ Neutral-Point Treatment	Description
Resistance-Grounded	In the resistance-grounded system, the ohmic/inductive ground fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • Dir. measuring method = cos φ • φ correction = -45.0° Set the Min.polar.3I0> for dir.det. and 3I0> threshold value parameters to a value below the minimum ground fault current to be expected.

Parameter: α1 reduction dir. area, α2 reduction dir. area

- Recommended setting value (_:105) α1 reduction dir. area = 2°
- Recommended setting value (_:106) α2 reduction dir. area = 2°

With the α1 reduction dir. area and α2 reduction dir. area parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil-ground system in feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: V0> threshold value

- Default setting (_:103) V0> threshold value = 30.000 V

The V0> threshold value parameter allows you to set the zero-sequence voltage sensitivity of the stage. Set the threshold value smaller than the minimum absolute value of the zero-sequence voltage V0 that must still be detected.

Parameter: Dir. determination delay

- Default setting (_:104) Dir. determination delay = 0.00 s

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 2.0 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> cos/sinφ#				
_:1	3I0> cos/sinφ#:Mode		• off • on • test	off
_:2	3I0> cos/sinφ#:Operate & flt.rec. blocked		• no • yes	no
_:10	3I0> cos/sinφ#:Blk. by meas.-volt. failure		• no • yes	yes
_:27	3I0> cos/sinφ#:Blk. w. inrush curr. detect.		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:110	3I0> cos/sinφ#:Blk. after fault extinction		• no • yes	yes
_:108	3I0> cos/sinφ#:Directional mode		• forward • reverse	forward
_:109	3I0> cos/sinφ#:Dir. measuring method		• cos φ • sin φ	cos φ
_:107	3I0> cos/sinφ#:φ correction		-45 ° to 45 °	0°
_:102	3I0> cos/sinφ#:Min.polar.3I0> for dir.det.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 35.000 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 35.000 A	0.150 A
_:105	3I0> cos/sinφ#:α1 reduction dir. area		1 ° to 15 °	2°
_:106	3I0> cos/sinφ#:α2 reduction dir. area		1 ° to 15 °	2°
_:101	3I0> cos/sinφ#:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:103	3I0> cos/sinφ#:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	3I0> cos/sinφ#:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> cos/sinφ#:Operate delay		0.00 s to 60.00 s	2.00 s

6.15.4.4 Information List

No.	Information	Data Class (Type)	Type
3I0> cos/sinφ#			
_:81	3I0> cos/sinφ#:>Block stage	SPS	I
_:501	3I0> cos/sinφ#:>Block delay & op.	SPS	I
_:54	3I0> cos/sinφ#:Inactive	SPS	O
_:52	3I0> cos/sinφ#:Behavior	ENS	O
_:53	3I0> cos/sinφ#:Health	ENS	O
_:60	3I0> cos/sinφ#:Inrush blocks operate	ACT	O
_:55	3I0> cos/sinφ#:Pickup	ACD	O
_:56	3I0> cos/sinφ#:Operate delay expired	ACT	O
_:57	3I0> cos/sinφ#:Operate	ACT	O
_:302	3I0> cos/sinφ#:Ground fault	ACD	O

6.15.5 Directional Transient Ground-Fault Stage

6.15.5.1 Description

Overview

Ground faults occurring in arc-suppression-coil-ground systems quite often extinguish a short time after the ignition, mostly within a few milliseconds. Such transient occurrences are called transient ground faults. In order to detect the ground-fault direction, based on these transient occurrences, a special method of measurement is required that can also capture high frequencies. Conventional methods based on phasor calculations are not suitable. Even for ground faults lasting for a short time, usually, a high-frequency charging process occurs in healthy phases. The transient charging process is evaluated by the transient ground-fault method of measurement to determine the ground-fault direction. An integrating method of measurement ensures a high degree of sensitivity and a positive stability against parasitic signals in the zero-sequence system.

Since permanent ground faults also start with the transient charging process of flawless wires, these errors will be detected as well.

This process is most suitable for the use in closed loops or meshed systems. Operational, circulating zero-sequence currents are eliminated and therefore, cannot affect the directional result.

Stage-Control Logic

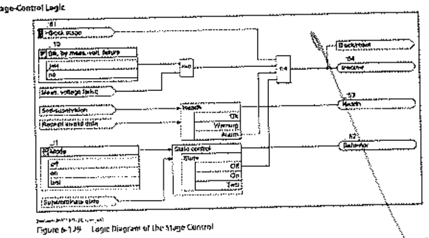

Figure 6-129 Logic Diagram of the Stage Control

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset. The following blocking options are available for the stage:

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

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

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Logic of the Transient Ground-Fault Functionality

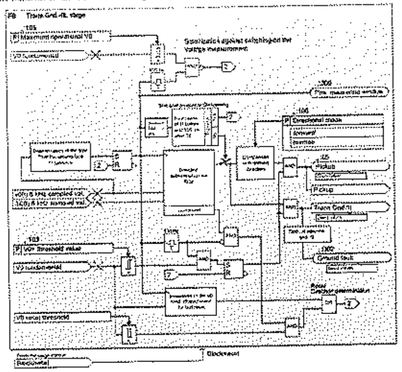

Figure 6-130 Logic Diagram of the Directional Transient Ground-Fault Stage

Measured Values, Method of Measurement

The zero-sequence values of zero-sequence voltage and zero-sequence current are measured directly or calculated from the phase variables. When measuring directly, the following is detected:

- Zero-sequence voltage on the broken-delta winding
- Zero-sequence current via Holmgreen connection or via core balance current transformer

The voltage measured on the broken-delta winding will be converted to zero-sequence voltage V_0.

The instantaneous values of the zero-sequence voltage V0(t) that are sampled at a high frequency (8 kHz) serve to determine the point in time of the ground fault occurrence T0.

The instantaneous values of the zero-sequence voltage V0(t) and the ground current 3I0(t), which are sampled at a high frequency (8 kHz), are the basis for direction determination.

The fundamental-component values of the zero-sequence voltage V0 serve to release the directional result and the pickup as well as a criterion for the stabilization against switching operations.

The positive-sequence system (if it exists as a measured value) serves as an additional criterion for the stabilization against switching operations.

The fundamental-component values V0 and 3I0 will be used in the optional trip logic.

Operational, meaning circulating zero-sequence currents, can occur in closed loops or meshed systems. This type of zero-sequence current is also present in case of a failure and can falsify the directional result. Therefore, an operational zero-sequence current is eliminated.

Determining the Time of the Ground-Fault Ignition

The algorithm uses the evaluation of the instantaneous values of the zero-sequence voltage to verify continuously if a ground fault occurred. This takes place regardless of whether the set threshold value for V0 is exceeded. If a ground fault occurred, the measuring window for determining the direction is positioned and the direction determination is performed. The position of the measuring window is logged via the indication *Pos. measuring window* (in FB General). The precise identification of the time T0 at which the ground fault occurred is decisive for the correct direction determination.

Determination of Direction, Method of Measurement

The active energy of the zero-sequence system is calculated for the direction determination. Once the ground fault occurrence has been detected, the active energy will be calculated across approximately 1 cycle frequency. If the active energy of the zero-sequence system is negative, a forward fault is present; otherwise it is a backward fault.

Direction Result Message, Pickup

Determining the time of the ground-fault ignition and the direction is always done with maximum sensitivity. With the parameter V0> threshold value, you define the sensitivity for the indication of the direction and the pickup of the stage.

If the fundamental-component value of the zero-sequence voltage V0 exceeds the associated threshold value (V0> threshold value parameter) within 100 ms after detecting the ground fault ignition, the direction result will be reported. In this way, high-impedance ground faults are also reported in which the zero-sequence system values rise only slowly, and, for this reason, the occurrence of the ground fault is detected noticeably earlier than the exceedance of the parameterized threshold value.

The direction result will be reported to the function via the *(_:302) Ground fault* of the function block General information. This indication is reported irrespective of the parameterized direction of the function. If the determined direction corresponds with the parameterized direction (parameter Directional mode), a pickup occurs.

Reset of the Algorithm

To allow a new directional measurement, the algorithm needs to be reset. The normal reset takes place when the fundamental component of the zero sequence voltage V0 drops below the V0 reset threshold. This reset threshold is a small device-internal V0 threshold. It is also depending on an operational V0 and is thus a dynamic threshold. The threshold value is 3.0 V secondary without dynamic influence.

Stabilization against Switching Operations

Switching operations in the system to be protected can cause transient signals in the zero sequence system. The stage is stabilized against possible overfunction due to switching operations.

The following mechanisms are applied:

- For reporting the direction result, the fundamental-component value of the zero-sequence voltage must exceed the V0> threshold value in a time slot of 100 ms after the ground fault extinction. This effectively suppresses wrong indications as a result of switching operations.
- The fundamental-component value of the zero-sequence voltage V0 is not influenced by switching operations and is thus a good criterion for distinguishing the ground fault from a switching procedure. The condition that the fundamental-component value must exceed the V0> threshold value for reporting the direction result effectively suppresses switching operations.

  For rare cases in which high zero-sequence voltages occur over longer time ranges after switching off the feeder or line, a criterion on the basis of the positive-sequence system current is also effective. This criterion compares the positive-sequence system current before and after the transient event and thus detects a disconnection. In case of disconnection, the direction result is not reported.

  Through stabilization mechanisms, the direction result is reported 100 ms after the ground-fault ignition. Thus a pickup occurs with a 100-ms delay.

  If the stage is used in a 1-phase function group, the additional criterion via the positive-sequence system current is not effective.
- The function detects transient occurrences in the zero sequence voltage. In systems with operational zero-sequence voltages, if the measuring voltage is switched on, the function can internally be started. If the fundamental-component value of the zero-sequence voltage does not exceed the threshold of the Maximum operational V0 parameter in a time slot of 100 ms after the function start, the function is reset internally.

Trip Logic

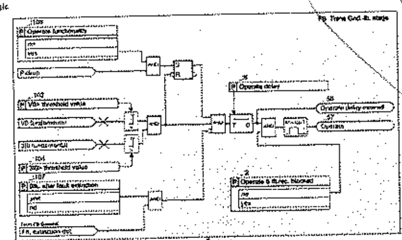

Figure 6-131 Trip Logic Diagram

In many applications, the transient ground-fault stage is used only to indicate the direction. In this case, the trip logic is not required and remains disabled. However, this stage can also be used to disable a permanent ground fault. For this, you enable the optional trip logic with the Operate functionality parameter. If the fundamental-component values V0 and 3I0 exceed the set threshold values, the operate delay (Operate delay parameter) starts with the pickup. In order to start the operate delay, the threshold values must be

exceeded during the time delay. The process of the operate delay will be indicated. If the Operate & flt.rec. blocked setting is set to no, the pickup indication is sent.

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value cycle of the zero-sequence voltage, the fault extinction of the ground fault can be detected faster than via the dropout of the V0 fundamental-component value under the pickup value. The fast detection of the fault extinction (see function block General information) blocks the tripping time delay. When using the parameter Blk. after fault extinction, this accelerated blocking mechanism can be enabled or disabled.

6.15.5.2 Application and Setting Notes

Parameter: Operate functionality

- Default setting (_:108) Operate functionality = no

If the transient ground-fault stage is used only to indicate the direction, this optional trip logic is not required and remains disabled. If the transient ground-fault stage is used to disable permanent faults as well, this optional trip logic is enabled. Pickup of the stage will initiate the tripping delay.

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

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

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

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

- The device-internal supervision function Measuring-voltage failure detection is configured and enabled.
- The binary input signal >Open of the function block Voltage transformer circuit breaker is linked with the voltage transformer circuit breaker.

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

Parameter: Blk. after fault extinction

- Recommended setting value (_:107) Blk. after fault extinction = yes

If the Blk. after fault extinction parameter is set to yes, the tripping delay is reset after the detection of the fault extinction. Therefore, if the tripping delay is set for a short time, the possibility of an overfunction is avoided. The reason for an overfunction is a slower attenuation in the zero-sequence system following the fault extinction. Siemens recommends keeping this default setting if the stage is used for tripping. If you are using the stage only for reporting or for detecting intermittent faults, you have to disable the blocking.

Parameter: Directional mode

- Default setting (_:106) Directional mode = forward

When a fault is detected, the selection of the parameter Directional mode defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: V0> threshold value

- Default setting (_:103) V0> threshold value = 15.000 V

With the parameter V0> threshold value, you define the sensitivity for the indication of the direction and the pickup of the stage.

Note that the sensitivity of the direction determination itself is not thereby changed. The direction determination always works with maximum sensitivity.

Should high-resistive ground faults be reported as well, very sensitive settings are possible, for example, V0> threshold value = 5 V secondary.

Parameter: Maximum operational V0

- Recommended setting value (_:105) Maximum operational V0 = 3.000 V

The setting of the Maximum operational V0 parameter is in conjunction with the stabilization against switching operations.

The setting is made with reference to the zero-sequence voltage V0 according to its definition.

Network Structure	Description
Radial system	In the primary system, no operational zero-sequence voltages are present. A measured zero-sequence voltage results from tolerances within the voltage measurement, for example, from the voltage transformers. Siemens recommends using the default value of 3.000 V.
Ring network, meshed network	Operational zero-sequence voltages can occur in such networks. The secondary operational zero-sequence voltages can be determined by reading the residual voltage $V_{N,sec}$ or the zero-sequence voltage $V_{0,sec}$ under the symmetrical components from the device or via DIGSI. In case you read the secondary residual voltage $V_{N,sec}$, you convert it to $V_{0,sec}$ with the Matching ratio Vph / VN parameter. You can find more information in chapter 6.1.4 Application and Setting Notes for Measuring-Point Voltage 3-Phase (V-3ph). If $V_{0,sec}$ is greater than 2.5 V, the value of Maximum operational V0 shall be increased to $V_{0,sec} \cdot 1.2$. Example: $V_{N,sec}$ = 5.000 V Matching ratio Vph / VN = √3 $V_{0,sec}$ = 5.000 V · √3 / 3 = 2.887 V Maximum operational V0 = 2.887 V · 1.2 = 3.464 V In most cases, the operational zero-sequence voltages will be smaller than 2.500 V. Siemens recommends using the default value of 3.000 V.

Parameter: 3I0> threshold value

- Default setting (_:104) 3I0> threshold value = 0.030 A

The setting is significant only for optional trip logic for switching off permanent ground faults. Select the setting such that the static ground fault current exceeds the threshold value.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 0.50 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

The setting of the Operate delay depends on the specific application. Ensure that the pickup is delayed by 100 ms with regard to the time of the ground-fault ignition.

6.15.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Trans. Gnd. flt#				
_:1	Trans.Gnd.flt#:Mode		• off • on • test	off
_:2	Trans.Gnd.flt#:Operate & flt.rec. blocked		• no • yes	no
_:10	Trans.Gnd.flt#:Blk. by meas. volt. failure		• no • yes	yes
_:107	Trans.Gnd.flt#:Blk. after fault extinction		• no • yes	yes
_:108	Trans.Gnd.flt#:Operate functionality		• no • yes	no
_:106	Trans.Gnd.flt#:Directional mode		• forward • reverse	forward
_:103	Trans.Gnd.flt#:V0> threshold value		0.300 V to 200.000 V	25.981 V
_:104	Trans.Gnd.flt#:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:6	Trans.Gnd.flt#:Operate delay		0.00 s to 60.00 s	0.50 s
_:105	Trans.Gnd.flt#:Maximum operational V0		0.300 V to 340.000 V	3.000 V

6.15.5.4 Information List

No.	Information	Data Class (Type)	Type
Trans. Gnd. flt#			
_:81	Trans.Gnd.flt#:>Block stage	SPS	I
_:54	Trans.Gnd.flt#:Inactive	SPS	O
_:52	Trans.Gnd.flt#:Behavior	ENS	O
_:53	Trans.Gnd.flt#:Health	ENS	O
_:55	Trans.Gnd.flt#:Pickup	ACD	O
_:56	Trans.Gnd.flt#:Operate delay expired	ACT	O
_:57	Trans.Gnd.flt#:Operate	ACT	O
_:302	Trans.Gnd.flt#:Ground fault	ACD	O

6.15.6 Usage Information for Detection of Intermittent Ground Faults

The stage type 3I0> with cos φ or sin φ measurement is suited for directional detection of intermittent ground faults. Many years of field experience and field tests have shown that the direction determination of this stage type reliably determines the direction of the current peaks. Between the current peaks, the direction is detected as unknown. To generate a tripping or an alarm, you can analyze the individual pickups of a stage (each directional pickup corresponds to a current peak) in a time-based way or count them via an additional user logic (CFC chart).

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You can also ensure the result in the user logic via a 2nd directional stage that works in the backward direction as well as a V0 stage.

You can operate a 3rd directional stage in parallel for detection of permanent ground faults.

In the following, certain settings are explained that are necessary for this application (detection of intermittent ground faults):

- Parameter: (_:102) Dropout delay
  The function must treat the intermittent process as one ground fault. For this, it is necessary that the indication Ground fault does not drop out between 2 consecutive current peaks. This is ensured via the Dropout delay parameter (FB General). A dropout delay of 1 s is a feasible value.
- Parameter: (_:104) Dir. determination delay
  You must set the delay of the direction determination to 0 s so that the direction of the current peaks can be determined.
- Parameter: (_:105) α1 reduction dir. area and (_:106) α2 reduction dir. area
  The current peaks show a clear ohmic component. With these parameters, you can limit the direction characteristic and ensure a reliable direction result.
  Siemens recommends setting both parameters to "0"
- Parameter: (_:110) Blk. after fault extinction
  To make possible a continuous and immediate detection of the current peaks, you must switch off the blocking after fault suppression.

No further parameters need particular consideration with regard to an intermittent ground fault. You can set these as for the detection of permanent ground faults.

6.15.7 Directional 3I0 Stage with φ(V0,3I0) Measurement

6.15.7.1 Description

Logic

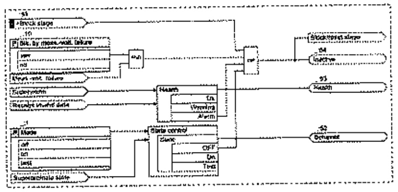

Figure 6-132 Logic Diagram of the Stage Control

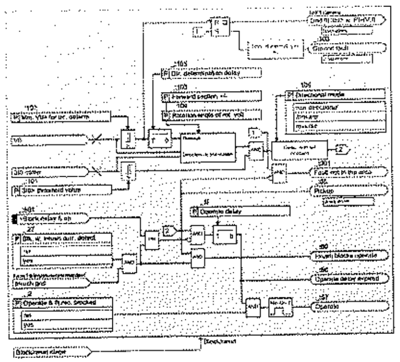

Figure 6-133 Logic Diagram of the Directional 3I0 Stage with φ(V0,3I0) Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken-delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the defining equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, Method of Measurement

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically.

Depending upon the settings of the Connection type and Measuring point I-3ph parameters, as well as the current terminal blocks used, different linearity and setting ranges result, refer for this to chapter 6.15.4.1 Description, Ground-Fault Detection, Pickup.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 vector exceeds the threshold value 3I0> threshold value and the absolute value of the zero-sequence voltage V0 vector exceeds the threshold value Min. V0> for dir. determ., the stage detects the ground fault. The direction determination (see in the following paragraph) is started when the zero-sequence voltage exceeds the threshold. The result from the direction determination is only valid if the absolute value of the ground current 3I0 vector has also exceeded its threshold value. The direction result is indicated via the Ground fault signal (in the General function block).

As long as the direction result equals the parameterized direction (parameter Directional mode), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero-sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands.

The direction is determined via the determination of the phase angle between the angle error compensated ground current 3I0com, and the rotated zero-sequence voltage V0, indicated in the following as reference voltage $V_{ref,rot}$. To take different system conditions and applications into account, the reference voltage can be rotated through an adjustable angle (Rotation angle of ref. volt. parameter). This moves the vector of the rotated reference voltage close to the vector ground current -3I0com. Consequently, the result of direction determination is as reliable as possible.

The rotated reference voltage $V_{ref,rot}$ and the Forward section +/- parameter define the forward and reverse area. The forward area results as range ± Δφ around the rotated reference voltage $V_{ref,rot}$. The value ± Δφ is set with the Forward section +/- parameter. The remaining area besides the forward area is the reverse area. Between the forward and reverse area, a hysteresis is defined, refer to Figure 6-134.

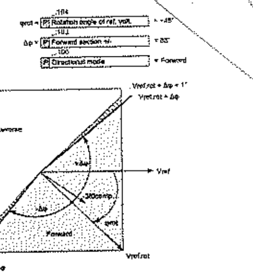

Figure 6-134 Directional Characteristic in Forward Mode

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Voltage transformer circuit breaker, which links in the tripping of the voltage transformer circuit breaker.

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

Blocking the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.7.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

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

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

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

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

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

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value (_:27) Blk. w. inrush curr. detect. = no

With the Blk. w. inrush curr. detect. parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains unaffected by an energizing procedure.

Parameter: Directional mode

- Default setting (_:106) Directional mode = forward

When a fault is detected, the selection of the parameter Directional mode defines whether the pickup of the stage occurs in forward or reverse direction.

When the parameter Directional mode is set as non-directional, the direction determination is not considered. The pickup condition depends only on the absolute values 3I0 and V0 and the respective thresholds.

Parameter: Rotation angle of ref. volt., Forward section +/-

- Default setting (_:104) Rotation angle of ref. volt. = -45°
- Default setting (_:103) Forward section +/- = 88°

With the Rotation angle of ref. volt. and Forward section +/- parameters, you set the direction characteristic, that is, the areas of forward and reverse. With this, you set the direction characteristic according to the system conditions and the neutral-point treatment.

Typical settings for the Rotation angle of ref. volt. parameter are:

- Arc-suppression coil ground system: 0°
- Isolated system: +45°
- Grounded system: -45°

The Forward section +/- parameter can normally be left at its default setting. A reduction of the forward area by a few degrees is practical, for example in an arc-suppression-coil-ground system with long cable feeders, that generate high capacitive fault currents.

Parameter: Min. V0> for dir. determ.

- Default setting (_:102) Min. V0> for dir. determ. = 2.000 V

With the Min. V0> for dir. determ. parameter, you determine the minimum voltage V0 necessary for the release of the direction determination that must be attained within the time delay Dir. determination delay.

Parameter: 3I0> threshold value

- Default setting (_:101) 3I0> threshold value = 0.050 A

The 3I0> threshold value parameter allows you to set the ground-current sensitivity of the stage. Set the threshold value lower than the minimum absolute value of the ground-fault current 3I0 that must still be detected.

Parameter: Dir. determination delay

- Default setting (_:105) Dir. determination delay = 0.10 s

The start of the ground fault normally shows a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 0.50 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.7.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> φ(V,I) #				
_:1	3I0> φ(V,I) #:Mode		• off • on • test	off
_:2	3I0> φ(V,I) #:Operate & flt.rec. blocked		• no • yes	no
_:10	3I0> φ(V,I) #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	3I0> φ(V,I) #:Blk. w. inrush curr. detect.		• no • yes	no
_:106	3I0> φ(V,I) #:Directional mode		• non-directional • forward • reverse	forward
_:104	3I0> φ(V,I) #:Rotation angle of ref. volt.		-180 ° to 180 °	-45 °
_:103	3I0> φ(V,I) #:Forward section +/-		0 ° to 180 °	88 °
_:102	3I0> φ(V,I) #:Min. V0> for dir. determ.		0.300 V to 200.000 V	2.000 V
_:101	3I0> φ(V,I) #:3I0> threshold value	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:105	3I0> φ(V,I) #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	3I0> φ(V,I) #:Operate delay		0.00 s to 60.00 s	0.50 s

6.15.7.4 Information List

No.	Information	Data Class (Type)	Type
3I0> φ(V,I) #			
_:81	3I0> φ(V,I) #:>Block stage	SPS	I
_:501	3I0> φ(V,I) #:>Block delay & op.	SPS	I
_:54	3I0> φ(V,I) #:Inactive	SPS	O
_:52	3I0> φ(V,I) #:Behavior	ENS	O
_:53	3I0> φ(V,I) #:Health	ENS	O
_:301	3I0> φ(V,I) #:Fault not in trip area	SPS	O
_:60	3I0> φ(V,I) #:Inrush blocks operate	ACT	O
_:302	3I0> φ(V,I) #:Ground fault	ACD	O
_:55	3I0> φ(V,I) #:Pickup	ACD	O
_:56	3I0> φ(V,I) #:Operate delay expired	ACT	O
_:57	3I0> φ(V,I) #:Operate	ACT	O

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6.15.8 Directional V0 Stage with G0 or B0 Measurement

6.15.8.1 Description

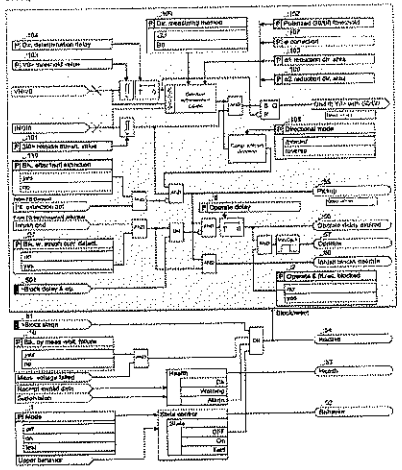

Figure 6-135 Logic Diagram of the Directional V0 Stage with G0 or B0 Measurement

Measured Value V0, Method of Measurement

The device measures the residual voltage at the broken delta winding. The measured voltage is converted to the zero-sequence voltage V0. If the residual voltage is not available to the device as a measurand, the zero-sequence voltage V0 is calculated from the measured phase-to-ground voltages VA, VB, and VC using the definition equation.

This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.

Measured Value 3I0, G0, B0, Method of Measurement

The function usually evaluates the ground current 3I0 sensitively measured via a core balance current transformer, this current being converted with the voltage V0 into the admittance Y0 = G0 + jB0. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 calculated from the phase currents. This results in a very large linearity and settings range.

The method of measurement processes the sampled current values and filters out the fundamental component numerically. The methods of measurement are characterized by high accuracy and by insensitivity to harmonics, especially the 3rd and 5th harmonics frequently present in the ground-fault (leakage) current.

Ground-Fault Detection, Pickup

If the absolute value of the ground current 3I0 exceeds the threshold value 3I0> release thresh. value and the absolute value of the zero sequence voltage V0 exceeds the threshold value V0> threshold value, the stage recognizes the ground fault. The calculation of G0 or B0 is started with exceeding the threshold values one then, the direction determination (see the following) is performed. The direction result is indicated via the *Ground fault* signal (in the General function block). If the direction result equals the parameterized direction (parameter Directional mode), the stage picks up.

Direction Determination

Exceeding the threshold values by the zero sequence voltage V0 is a criterion for the ground fault. The direction determination can be delayed from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady state measurands. The result from the direction determination is only valid if the absolute value of the ground current 3I0 has also exceeded its release threshold value. The following figure shows an example of the direction determination in the complex phasor diagram for the G0 direction measurement method with a correction value of the direction straight line from 0 (Parameter φ correction). The example is suitable for the determination of the ground fault direction in an arc suppression-coil-ground system where the value G0 is decisive for the direction determination.

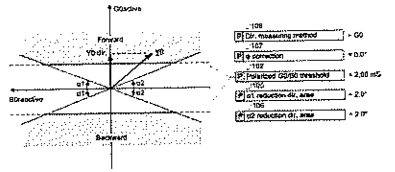

Figure 6-136 Direction-Characteristic Curve for the G0 Measurement

The zero-sequence voltage V0 is generally the reference value for the real axis and is identical to the G0 axis. The axis of symmetry of the direction-characteristic curve coincides with the B0 (reactive) axis for this example. For the direction determination, the component of the admittance perpendicular to the set direction-characteristic curve (= axis of symmetry) is decisive G0dir (= Y0dir). In this example, this is the active component G0active of the admittance Y0. The conductance G0dir. (here = G0active) is calculated and

compared with the setting value Polarized G0/B0 threshold. If the conductance G0dir. exceeds the positive setting value, the direction is forward. If the conductance G0dir. exceeds the negative setting value, the direction is backward. In the range in between, the direction is undetermined.

With the α1 reduction dir. area and α2 reduction dir. area parameters, you can limit the forward and backward ranges as shown in Figure 6-137. With this, the direction determination is secured in case of high currents in the direction of the axis of symmetry.

The symmetry axis can be turned via a correction angle (φ correction parameter) in a range of ±45°. Through this, it is possible, for example, to attain the greatest sensitivity in grounded systems in the resistive-inductive range with a -45° turn. In the case of electric machines in busbar connection on the isolated system, the greatest sensitivity in the resistive-capacitive range can be attained with a turn of +45° (see following figure).

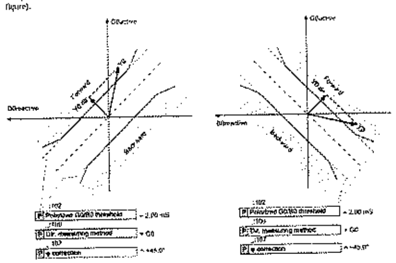

Figure 6-137 Turning the Direction-Characteristic Curves with G0 Measurement with Angle Correction

If you set the Dir. measuring method parameter to B0 and the φ correction parameter to 0, the axis of symmetry of the direction-characteristic curve coincides with the G0 and V0 axes. Since the component of the admittance Y0 perpendicular to the direction-characteristic curve (= axis of symmetry) is decisive (B0dir. (= Y0dir.)), here, the susceptance B0 (reactive) is used in the direction determination. If the susceptance B0dir. (B0reactive) exceeds the negative setting value Polarized G0/B0 threshold, the direction is forward. If the susceptance B0dir. exceeds the positive setting value, the direction is backward. In the range in between, the direction is undetermined.

This direction measurement that is appropriate for the determination of ground-fault direction in isolated systems.

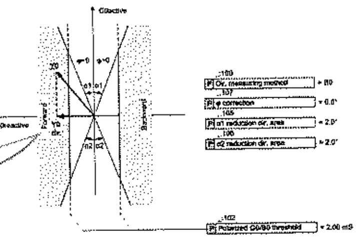

Figure 6-138 Direction Characteristic Curve for the B0 Measurement

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked-up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the Measuring-voltage failure detection function
- From an external source via the binary input signal >Open of the function block Voltage transformer circuit breaker, which links in the tripping of the voltage-transformer circuit breaker.

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

Blocking the Pickup with Detection of the Fault Extinction

Using the evaluation of the instantaneous value developing of the zero-sequence voltage, the fault extinction can be recognized faster than via the dropout of the V0 fundamental-component value under the pickup value. The pickup of the stage is blocked with the fast detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. With the Blk. after fault extinction parameter, you enable or disable this accelerated detection of the fault extinction.

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is initiated.

Blocking the Operate Indication via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking and fulfilled pickup conditions, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the pickup conditions are still met, the time delay is started.

6.15.8.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

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

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

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

- The device-internal supervision function Measuring-voltage failure detection is configured and enabled.
- The binary input signal >Open of the function block Voltage transformer circuit breaker is linked with the voltage transformer circuit breaker.

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

Parameter: Blk. w. inrush curr. detect.

- Recommended setting value (_:27) Blk. w. inrush curr. detect. = no

With the Blk. w. inrush curr. detect. parameter, you specify whether the operate is blocked during detection of an inrush current.

Siemens recommends disabling the blocking. The fundamental component of the zero-sequence voltage is a reliable criterion for the ground fault and remains untouched by an enabling procedure.

Parameter: Blk. after fault extinction

- Recommended setting value (_:110) Blk. after fault extinction = yes

If the Blk. after fault extinction parameter is set to yes, the pickup is blocked after detection of the fault extinction. With this, the pickups are avoided due to the decay procedure in the zero-sequence system after the fault extinction. Siemens recommends using the default setting.

Parameter: Directional mode

- Default setting (_:108) Directional mode = forward

When a fault is detected, the selection of the parameter Directional mode defines whether the pickup of the stage occurs in forward or backward direction.

Parameter: Dir. measuring method, φ correction, Polarized G0/B0 threshold, 3I0> release thresh. value

- Default setting (_:109) Dir. measuring method = G0
- Default setting (_:107) φ correction = 0.0°
- Default setting (_:102) Polarized G0/B0 threshold = 2.00 mS
- Default setting (_:101) 3I0> release thresh. value = 0.002 A

These parameters are used to define the direction characteristic of the stage. The direction characteristic to use is dependent on the neutral point treatment of the system.

Note that, for the direction determination, basically only the component of the admittance perpendicular to the set direction-characteristic curve is decisive, see chapter 6.15.8.1 Description. This admittance component is compared to the threshold value Polarized G0/B0 threshold. In contrast, the absolute value of the current 3I0 is compared with the 3I0> release thresh. value parameter.

System Type/ Neutral-Point Treatment	Description
Grounded	In the arc-suppression-coil-ground system, the watt leakage current 3I0 · cos φ of the arc suppression coil is decisive for the direction determination. To evaluate the watt leakage current, set the parameters as follows: • Dir. measuring method = G0 • φ correction = 0.0° The direction determination for a ground fault is made more difficult in that a much larger reactive current of capacitive or inductive character is superimposed on the small watt leakage current. Therefore, depending on the system configuration and the fault evaluation, the total ground current supplied to the device can vary considerably in its values regarding the magnitude and the phase angle. However, the device should only evaluate the active component of the ground fault current. This requires extremely high accuracy, particularly regarding the phase-angle measurement of all the instrument transformers. Furthermore, the device must not be set to operate too sensitively. A reliable direction measurement can only be expected with connection to a core balance current transformer. For the setting of the Polarized G0/B0 threshold parameter, the following formula applies: $G0 < k_s \cdot \frac{I_{Gactive}}{\sqrt{3}V_{rated}} + \frac{I_{Gmin}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) $I_{Gactive}$: Active component of the ground fault current (watt leakage current) of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{Gmin}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) V0>: Pickup threshold of the residual voltage = $0.1\sqrt{3}V_{rated}$ If a parallel resistor Rp is used on the arc suppression coil, the threshold value G0 must also be smaller than: $G0 < \frac{1}{k_s} \cdot \frac{I_{Rp}}{\sqrt{3}V_{rated}}$ where: k_s: Safety margin ≥ 1.5 I_{Rp}: Secondary rated current of the parallel resistor V_{rated}: Secondary rated voltage in the healthy case The 3I0> release thresh. value parameter can be set to half of the expected measuring current and here, the entire zero-sequence current can be put to use.

System Type/ Neutral-Point Treatment	Description
Isolated	In the isolated system, the capacitive ground reactive current 3I0 · sin φ is decisive for the direction determination. To evaluate the capacitive ground reactive current, set the parameters as follows: • Dir. measuring method = B0 • φ correction = 0.0° In isolated systems, a ground fault allows the capacitive ground-fault currents of the entire electrically connected system, except for the ground current in the faulty cable itself, to flow through the measuring point as the latter flows directly away from the fault location (that is, not via the measuring point). The following formula can be used to determine the pickup value of the Polarized G0/B0 threshold parameter. $B0 < \frac{I_{Gmin}}{V0>}$ where: I_{Gmin}: Ground current in the healthy case V0>: Pickup threshold of the residual voltage = $0.02\sqrt{3}V_{rated}$ In healthy operation, B0 ≈ 0. For the 3I0> release thresh. value parameter, select around half of this capacitive ground-fault current flowing via the measuring point.
Resistance-Grounded	In the resistance-grounded system, the ohmic-inductive ground-fault current is decisive for the direction determination. To evaluate this short-circuit current, set the parameters as follows: • Dir. measuring method = G0 • φ correction = -45.0° For the setting of the Polarized G0/B0 threshold parameter, the rule of thumb is: Set the pickup value according to the following formula where only the active ground fault current can be put into use. $G0 < k_s \cdot \frac{I_{Gactive}}{\sqrt{3}V_{rated}} + \frac{I_{Gmin}}{V0>}$ where: k_s: Safety margin, k_s = 1.2 (cable networks), k_s = 2.0 (overhead lines) $I_{Gactive}$: Active component of the ground-fault current of the protected line V_{rated}: Secondary rated voltage in the healthy case I_{Gmin}: Min. ground current in the healthy case, 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer) V0>: Pickup threshold of the residual voltage = $0.02\sqrt{3}V_{rated}$ The 3I0> release thresh. value parameter must be set to a value below the minimum expected ground-fault current.

Parameter: α1 reduction dir. area, α2 reduction dir. area

- Recommended setting value (_:105) α1 reduction dir. area = 2°
- Recommended setting value (_:106) α2 reduction dir. area = 2°

With the α1 reduction dir. area and α2 reduction dir. area parameters, you specify the angle for the limitation of the direction range. Siemens recommends using the default setting of 2°.

In an arc-suppression-coil ground system on feeders with a very large reactive current, it can be practical to set a somewhat larger angle α1 to avoid a false pickup based on transformer and algorithm tolerances.

Parameter: V0> threshold value

- Default setting (_:103) V0> threshold value = 30.000 V

The V0> threshold value parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: Dir. determination delay

- Default setting (_:104) Dir. determination delay = 0.10 s

The start of the ground fault normally indicates a significant transient behavior. This can lead to an incorrect direction decision. The direction determination can be delayed for this reason from the occurrence of the zero-sequence voltage with the Dir. determination delay parameter to achieve steady-state measurands. The duration of the transient cycle is determined from the system conditions and the respective fault characteristics. If you have no knowledge of a suitable time delay, Siemens recommends keeping the default setting.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 2.0 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.8.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0> G0/B0 #				
_:1	V0> G0/B0 #:Mode		• off • on • test	off
_:2	V0> G0/B0 #:Operate & flt.rec. blocked		• no • yes	no
_:10	V0> G0/B0 #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	V0> G0/B0 #:Blk. w. inrush curr. detect.		• no • yes	no
_:110	V0> G0/B0 #:Blk. after fault extinction		• no • yes	yes
_:108	V0> G0/B0 #:Directional mode		• forward • reverse	forward
_:109	V0> G0/B0 #:Dir. measuring method		• G0 • B0	G0
_:107	V0> G0/B0 #:φ correction		-45 ° to 45 °	0 °
_:102	V0> G0/B0 #:Polarized G0/B0 threshold		0.10 mS to 100.00 mS	2.00 mS
_:105	V0> G0/B0 #:α1 reduction dir. area		1 ° to 15 °	2 °
_:106	V0> G0/B0 #:α2 reduction dir. area		1 ° to 15 °	2 °

Addr.	Parameter	C	Setting Options	Default Setting
_:101	V0> G0/B0 #:3I0> release thresh. value	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:103	V0> G0/B0 #:V0> threshold value		0.300 V to 200.000 V	30.000 V
_:104	V0> G0/B0 #:Dir. determination delay		0.00 s to 60.00 s	0.10 s
_:6	V0> G0/B0 #:Operate delay		0.00 s to 60.00 s	2.00 s

6.15.8.4 Information List

No.	Information	Data Class (Type)	Type
V0> G0/B0 #			
_:81	V0> G0/B0 #:>Block stage	SPS	I
_:501	V0> G0/B0 #:>Block delay & op.	SPS	I
_:54	V0> G0/B0 #:Inactive	SPS	O
_:52	V0> G0/B0 #:Behavior	ENS	O
_:53	V0> G0/B0 #:Health	ENS	O
_:60	V0> G0/B0 #:Inrush blocks operate	ACT	O
_:55	V0> G0/B0 #:Pickup	ACD	O
_:56	V0> G0/B0 #:Operate delay expired	ACT	O
_:57	V0> G0/B0 #:Operate	ACT	O

6.15.9 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

6.15.9.1 Description

Logic

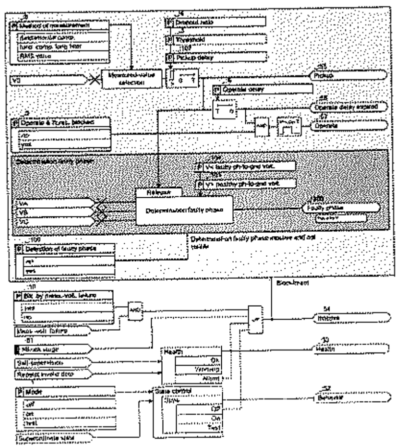

Figure 6-139 Logic Diagram of the Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage

Measured Value, Method of Measurement

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

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

- Measurement of the fundamental component (standard filter):
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically.
- Measurement of the RMS value (true RMS):
  This method of measurement determines the voltage amplitude from the sampled values according to the defining equation of the RMS value.
- Measurement of the fundamental component over 2 cycle filters with triangular window:
  This method of measurement processes the sampled voltage values and filters out the fundamental component numerically. The extended filter length compared to the standard filter and the use of the triangular window results in a particularly strong attenuation of harmonics and transient faults. The extended filter length causes the pickup time to increase slightly compared to the standard filter (see 12.16.x Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage).

Pickup, Dropout

The stage compares the Threshold with the zero-sequence voltage V_0. The Pickup delay parameter allows you to delay the pickup of the stage depending on the residual voltage.
With the Dropout ratio parameter, you can define the ratio of the dropout value to the Threshold.

Determination of the Faulty Phase

With the Detection of faulty phase parameter, you can enable or disable the determination of the ground-fault phase. Determining is released when the stage picks up. If 2 phases exceed the threshold value V> healthy ph-to-gnd volt. and one phase falls below the threshold value V< faulty ph-to-gnd volt., the last phase is determined to be faulty and is signaled as such.

Blocking the Stage

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

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

6.15.9.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Method of measurement

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

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

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Parameter Value	Description
fundamental comp.	This method of measurement suppresses the harmonics or transient voltage peaks. Siemens recommends using this setting as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example at capacitor banks).
fund. comp. long filter	To implement particularly strong damping of harmonics and transient faults, select this method of measurement. At 2 periods, the length of the filter is longer than that of the standard filter. Note that in this case the pickup time of the stage increases slightly (see 12.18 Non-Directional V0 Stage with Zero-Sequence Voltage/Residual Voltage).

Parameter: Pickup delay

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

The Pickup delay parameter allows you to delay the analysis of the measurand (to 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 (_:3) Threshold = 30 V

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

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

EXAMPLE
For an isolated system
The residual voltage is measured via the broken delta winding:

- If the ground fault is fully 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 on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/√3 = 57.7 V
  Setting value: 0.5 · 57.7 V = 28.9 V ≈ 30 V

Parameter: Dropout ratio

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

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

Parameter: Operate delay

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

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

Parameter: Blk. by meas.-volt. failure

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

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected.
A measuring-voltage failure can only be detected if one of the following 2 conditions is met:

- The device-internal supervision function Measuring-voltage failure detection is configured and enabled.
- The binary input signal >Open of the function block Voltage transformer circuit breaker is linked with the voltage transformer circuit breaker.

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

Parameter: Detection of faulty phase

- Default setting (_:109) Detection of faulty phase = no

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

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

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

- Default setting (_:104) V< faulty ph-to-gnd volt. = 30 V

Set the threshold value for determining which phase is affected by the ground fault in the V< faulty ph-to-gnd volt. parameter. The setting value is a phase-to-ground quantity.
The set value must be smaller than the minimum phase-to-ground voltage occurring during operation.
Siemens recommends using the default setting V< faulty ph-to-gnd volt. = 30 V.

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

- Default setting (_:101) V> healthy ph-to-gnd volt. = 70 V

Set the threshold value for the 2 healthy phases in the V> healthy ph-to-gnd volt. parameter. The setting value is a phase-to-ground measurand.
The set value must be above the maximum phase-to-ground voltage occurring during operation, but below the minimum phase-to-phase voltage present during operation. At V_{rated} = 100 V, the value has to be set to 70 V, for example. Siemens recommends using the default setting V> healthy ph-to-gnd volt. = 70 V.

Operation as Supervision Function

If you want the stage to have a reporting effect only, the generation of the operate indication and fault logging can be disabled via the (_:2) Operate & flt.rec. blocked parameter.

6.15.9.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
V0> #				
_:1	V0> #:Mode		• off • on • test	off
_:2	V0> #:Operate & flt.rec. blocked		• no • yes	no
_:10	V0> #:Blk. by meas.-volt. failure		• no • yes	yes
_:109	V0> #:Detection of faulty phase		• no • yes	no
_:8	V0> #:Method of measurement		• fundamental comp. • fund. comp. long filter • RMS value	fundamental comp.
_:3	V0> #:Threshold		0.300 V to 200.000 V	30.000 V
_:4	V0> #:Dropout ratio		0.90 to 0.99	0.95
_:107	V0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	V0> #:Operate delay		0.00 s to 60.00 s	3.00 s
_:101	V0> #:V> healthy ph-to-gnd volt.		0.300 V to 200.000 V	70.000 V
_:104	V0> #:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	30.000 V

6.15.9.4 Information List

No.	Information	Data Class (Type)	Type
V0> #			
_:81	V0> #:>Block stage	SPS	I
_:54	V0> #:Inactive	SPS	O
_:52	V0> #:Behavior	ENS	O
_:53	V0> #:Health	ENS	O
_:300	V0> #:Faulty phase	ACT	O
_:55	V0> #:Pickup	ACD	O
_:56	V0> #:Operate delay expired	ACT	O
_:57	V0> #:Operate	ACT	O

6.15.10 Non-Directional 3I0 Stage

6.15.10.1 Description

In the Directional sensitive ground-fault detection function, the Non-directional 3I0 stage also works on demand.

Logic

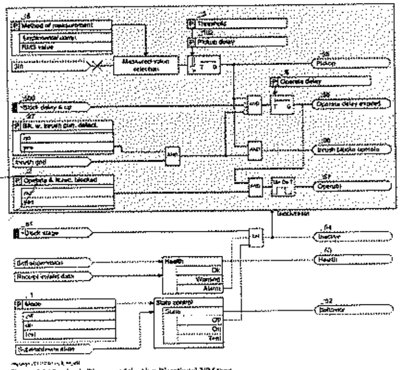

Figure 6-140 Logic Diagram of the Non-Directional 3I0 Stage

Measured Value 3I0

The function usually evaluates the sensitively measured ground current 3I0 via a core balance current transformer. Since the linearity range of the sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range.
Depending upon the settings of the Connection type and Measuring point I-3ph parameters, as well as the current terminal blocks used, different linearity and setting ranges result, refer for this to chapter 6.15.4.1 Description, Ground-Fault Detection, Pickup.

Method of Measurement

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

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

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

Blocking the Stage via Binary Input Signal

You can block the stage externally or internally via the binary input signal >Block stage. In the event of blocking, the picked up stage will be reset.

Blocking the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

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

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started.

6.15.10.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording and the fault log with the Operate & flt.rec. blocked parameter. In this case a ground-fault log is created instead of the fault log.

Parameter: Blk. w. inrush curr. detect.

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

With the Blk. w. inrush curr. detect. parameter, you determine whether the tripping is blocked during the detection of an inrush current.

Parameter: Method of measurement

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

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

Parameter Value	Description
fundamental comp.	Select this method of measurement if harmonics or transient current peaks are to be suppressed. Siemens recommends using this method as the standard method.
RMS value	Select this method of measurement if you want the stage to take harmonics into account (for example, at capacitor banks). For this method of measurement, do not set the threshold value of the stage to less than 0.1 I_{rated}.

Parameter: Threshold

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

The Threshold parameter allows you to set the threshold value of the ground current 3I0.

Parameter: Pickup delay

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

With the parameter Pickup delay you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 0.30 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.10.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
3I0> #				
_:1	3I0> #:Mode		• off • on • test	off
_:2	3I0> #:Operate & flt.rec. blocked		• no • yes	no
_:27	3I0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:8	3I0> #:Method of measurement		• fundamental comp. • RMS value	fundamental comp.
_:3	3I0> #:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.050 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.25 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.050 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.250 A
_:102	3I0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	3I0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.15.10.4 Information List

No.	Information	Data Class (Type)	Type
3I0> #			
_:81	3I0> #:>Block stage	SPS	I
_:500	3I0> #:>Block delay & op.	SPS	I
_:54	3I0> #:Inactive	SPS	O
_:52	3I0> #:Behavior	ENS	O
_:53	3I0> #:Health	ENS	O
_:60	3I0> #:Inrush blocks operate	ACT	O
_:55	3I0> #:Pickup	ACD	O
_:56	3I0> #:Operate delay expired	ACT	O
_:57	3I0> #:Operate	ACT	O

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6.15.11 Non-Directional Y0 Stage

6.15.11.1 Description

In the Directional sensitive ground-fault detection function, the Non-directional Y0 stage works on demand.

Logic

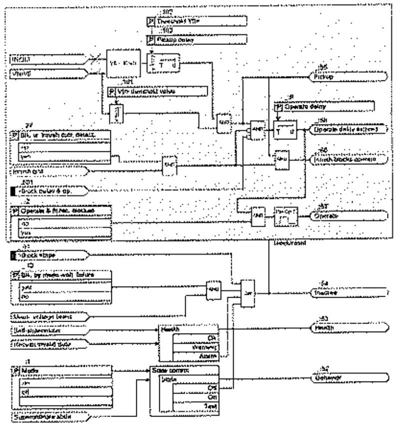

Figure 6-141 Logic Diagram of the Non-Directional Y0 Stage

Measured Value 3I0, Y0

The function evaluates the sensitively measured ground current 3I0 via a core balance current transformer, this current being converted with the voltage V0 into the admittance Y0=I0/V0. Since the linearity range of the

sensitive measuring input ends at approx. 1.6 A, for larger secondary ground currents, the function switches to the 3I0 current calculated from the phase currents. This results in a very large linearity and settings range. Depending on the settings of the Connection type and Measuring point I-3ph parameters, as well as the current terminal block used, different linearity and setting ranges result, refer for this to chapter 6.15.4.2 Description.

Blocking the Stage via Binary Input Signal

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

Blocking the Stage in Case of Measuring-Voltage Failure

The stage can be blocked if a measuring-voltage failure occurs. In the event of blocking, the picked up stage will be reset.

The following blocking options are available for the stage:

- From inside on pickup of the **Measuring-voltage failure detection** function
- From an external source via the binary input signal >Open of the function block **Voltage transformer circuit breaker**, which links in the tripping of the voltage-transformer circuit breaker.

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

Blocking of the Time Delay

You can use the binary input signal >Block delay & op. to prevent the start of the time delay and thus also the operate indication. A running time delay is reset. The pickup is indicated and a fault record is opened.

Blocking of the Operate Indication via the Device-Internal Inrush-Current Detection Function

The Blk. w. inrush curr. detect. parameter allows you to define whether the operate indication of the stage should be blocked by exceeding of the threshold values due to an inrush current. In case of a blocking, the stage picks up. The start of the time delay and the operate indication are blocked. The function indicates this through a corresponding indication. If the blocking drops out and the threshold value of the stage is still exceeded, the time delay is started.

6.15.11.2 Application and Setting Notes

Parameter: Operate & flt.rec. blocked

- Default setting (_:2) Operate & flt.rec. blocked = no

You can block the operate indication, the fault recording, and the fault log with the Operate & flt.rec. blocked parameter. In this case, a ground-fault log is created instead of the fault log.

Parameter: Blk. by meas.-volt. failure

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

You use the Blk. by meas.-volt. failure parameter to control the behavior of the stage when a measuring-voltage failure is detected. A measuring-voltage failure can only be detected if 1 of the following 2 conditions is met:

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

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.

Parameter Value	Description
no	The protection stage is not blocked.

Parameter: Blk. w. inrush curr. detect.

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

With the Blk. w. inrush curr. detect. parameter, you determine whether the operate is blocked during the detection of an inrush current.

Parameter: V0> threshold value

- Default setting (_:101) V0> threshold value = 5.000 V

The V0> threshold value parameter allows you to set the zero-sequence voltage sensitivity of the stage. The threshold value must be smaller than the minimum amount of the zero-sequence voltage V0 which must still be detected.

Parameter: Threshold Y0>

- Default setting (_:102) Threshold Y0> = 2.00 mS

With the parameter Threshold Y0>, you set the threshold value of the ground admittance Y0. If the ground admittance for the setting value is unknown, you can assume the following relation:

$$Y0 > k \cdot \frac{I_{c,sec}}{3V_{ph-gnd}} + \frac{3I_{0,sec}}{V0>}$$

k	Factor, takes into account the ohmic components of the current (1.2 for overhead lines, 1.0 ...1.05 for cable systems)
$I_{c,sec}$	Secondary capacitive ground-fault current for the protected line
V_{ph-gnd}	Secondary phase-to-ground voltage in the healthy case
$3I_{0,sec}$	Secondary ground current in the healthy case (resulting from transformer errors), 5 mA to 10 mA (core balance current transformer), 50 mA to 100 mA (Holmgreen transformer)
V0>	Secondary pickup threshold of the residual voltage

Parameter: Pickup delay

- Default setting (_:103) Pickup delay = 0.00 s

With the parameter Pickup delay, you set whether pickup of the stage is to be delayed or not. If the transient cycle of the ground fault occurrence should not be evaluated, set a delay of 100 ms, for example.

Parameter: Operate delay

- Default setting (_:6) Operate delay = 0.30 s

The parameterized time Operate delay determines the minimum time within which the pickup conditions must be present. An operate indication is only issued when this time is exceeded.

6.15.11.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Y0> #				
_:1	Y0> #:Mode		• off • on • test	off
_:2	Y0> #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:10	Y0> #:Blk. by meas.-volt. failure		• no • yes	yes
_:27	Y0> #:Blk. w. inrush curr. detect.		• no • yes	no
_:101	Y0> #:V0> threshold value		0.300 V to 200.000 V	5.000 V
_:102	Y0> #:Threshold Y0>		0.10 mS to 100.00 mS	2.00 mS
_:103	Y0> #:Pickup delay		0.00 s to 60.00 s	0.00 s
_:6	Y0> #:Operate delay		0.00 s to 60.00 s	0.30 s

6.15.11.4 Information List

No.	Information	Data Class (Type)	Type
Y0> #			
_:81	Y0> #:>Block stage	SPS	I
_:501	Y0> #:>Block delay & op.	SPS	I
_:54	Y0> #:Inactive	SPS	O
_:52	Y0> #:Behavior	ENS	O
_:53	Y0> #:Health	ENS	O
_:60	Y0> #:Inrush blocks operate	ACT	O
_:55	Y0> #:Pickup	ACD	O
_:56	Y0> #:Operate delay expired	ACT	O
_:57	Y0> #:Operate	ACT	O

6.16 Undercurrent Protection

6.16.1 Overview of Functions

The Undercurrent protection function (ANSI 37):

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

6.16.2 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.

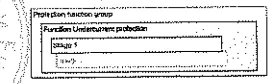

Figure 6-142 Structural Embedding of the Function

6.16.3 Stage Description Undercurrent Protection

Logic of the Stage

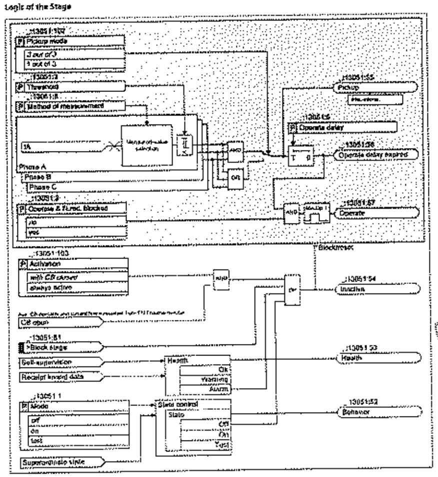

Figure 6-143 Logic Diagram of the Undercurrent Protection

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.

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- 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 conditions 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 condition that the auxiliary contacts indicate the circuit breaker as open.

6.16.4 Application and Setting Notes

Parameter: Activation

- Default setting (_:13051:103) 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.

6.16.5 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 @ 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

6.16.6 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			
_:13051:81	Stage 1:>Block stage	SPS	I

No.	Information	Data Class (Type)	Type
_: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

6.17 Negative-Sequence Protection

6.17.1 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

6.17.2 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.

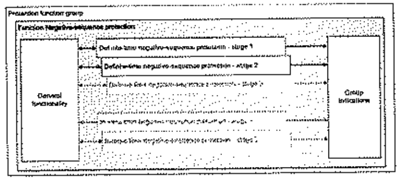

Figure 6-144 Structure/Embedding of the Function

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

6.17.3 General Functionality

6.17.3.1 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

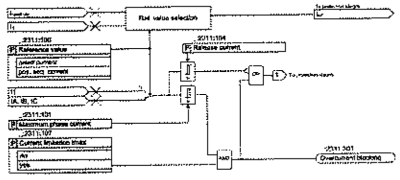

Figure 6-145 Logic Diagram of the General Functionality

(1) Switchover to I_1 with (_:2311:100) 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.

6.17.3.2 Application and Setting Notes

Parameter: Reference value

- Default setting (_:2311:100) 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 (_:2311:107) 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).

ВЯРНО С ОРИГИНАЛА

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6.17.4 Stage with Definite-Time Characteristic Curve

6.17.4.1 Stage Description

Logic of a Stage

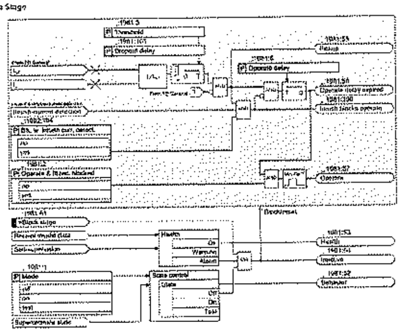

Figure 6-146 Logic Diagram of the Stage Negative-Sequence Protection with Definite-Time Characteristic Curve

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.

6.17.4.2 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 this parameter to yes.

6.17.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:106	General:Reference value		• neg. 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
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

6.17.4.4 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

6.17.5 Stage with Inverse-Time Characteristic Curve

6.17.5.1 Description

Logic of a Stage

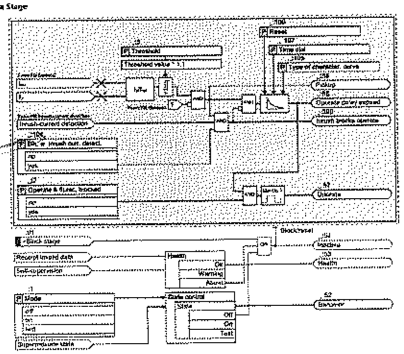

Figure 6-147 Logic Diagram of the Negative-Sequence Protection with Inverse-Time Characteristic Curve

Method of Measurement

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

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

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

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

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

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

Blocking of the Stage

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

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

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

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

6.17.5.2 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 12.20.2 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.

6.17.5.3 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
_:3	Inverse-T #:Threshold		5.0 % to 999.9 %	10.0 %
_:104	Inverse-T #:Blk. w. inrush curr. detect.		• no • yes	no
_:105	Inverse-T #:Type of character. curve			
_:106	Inverse-T #:Reset		• instantaneous • disk emulation	disk emulation
_:107	Inverse-T #:Time dial		0.05 to 15.00	1.00

6.17.5.4 Information List

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

ВЯРНО С ОРИГИНАЛА

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6.18 Directional Negative-Sequence Protection

6.18.1 Overview of Functions

The function Directional negative-sequence protection with current-independent time delay (ANSI 46) serves as the backup short-circuit protection for unbalanced faults.

With the negative-sequence system, various supervision and protection tasks can be realized, for example:

- Recording of 1 or 2-phase short circuits in the system with a higher sensitivity than in a classic overcurrent protection. The pickup value can be set under the rated object current.
- Recording of phase conductor interruptions in the primary system and in the current-transformer secondary circuits
- Location of short circuits or reversals in the connections to the current transformers
- Indication of unbalanced states in the energy system
- Protection of electrical machines following unbalanced loads that are caused by unbalanced voltages or conductor interruptions (for example, through a defective fuse)

6.18.2 Structure of the Function

The Directional negative-sequence protection with definite time delay function can be used in protection function groups with 3-phase current and voltage measurement.

The function comes factory-set with 1 stage. A maximum of 6 tripping stages can be operated simultaneously in the function.

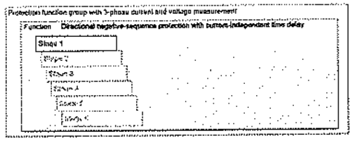

Figure 6-148 Structure/Embedding of the Function

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

6.18.3 Function Description

Stage Control

The following figure shows a stage control. It is available separately for each stage.

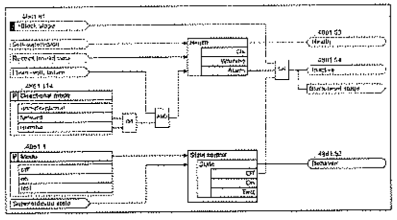

Figure 6-149 Stage Control of the Directional Negative-Sequence System Protection

In addition to the generally valid stage control, the stage is blocked in the event of a measuring voltage failure, provided the stage is working directionally.

Logic of the Stage

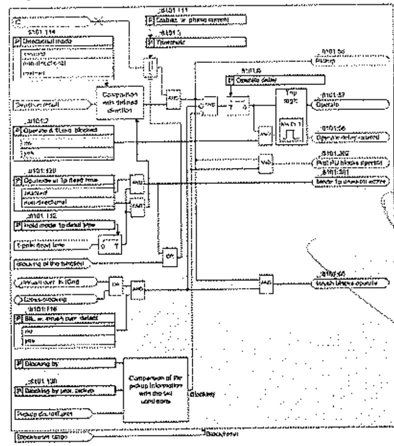

Figure 6-150 Logic Diagram of the Function Directional Negative-Sequence System Protection with Current-Independent Time Delay

Measurand

The negative sequence current I2 is used as a measurand. From the 3-phase currents, the fundamental phasors are determined via a 1-cycle filter and, corresponding with the definition equation of the symmetrical components, the negative sequence system is calculated from this.

Functioning

The stage picks up if the negative-sequence system current exceeds the set threshold value and the parameterized direction agrees with the measured direction. The pickup drops out if the negative-sequence system current falls below 95 % of the set threshold.

Stabilization with Phase Current

Unbalance in operation and unbalanced transformer ratios can lead to spurious pickups and incorrect tripping. In order to avoid this, the directional negative-sequence system stage is stabilized with the phase currents. The threshold value increases with rising phase currents (see next image).

You can change the stabilization factor (= gradient) via the Stabiliz. w. phase current parameter.

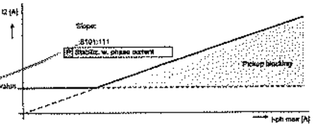

Figure 6-151 Stabilization with Phase Currents

Direction Determination

The direction determination takes place with the negative-sequence system measurements I2 and V2.

The forward and reverse region is defined through the parameters Angle forward α and Angle forward β (see next figure). The reference for the 2 angles that must be set is the positive real axis. The angles are positively defined in a mathematical sense (counter-clockwise). The region between the limit angle α and the limit angle β - counted from the former in a positive direction - is the forward region. The remaining region is the reverse region.

For determining of the direction, the function places the measuring current I2 on the real axis. If the phasor of the negative sequence system voltage V2 is located within the defined forward region, the function determines the direction as forward. In the other case, the function determines the direction as reverse.

The requirement for determining the direction is that the adjustable minimum variables have been exceeded for the negative-sequence system current and negative-sequence system voltage (parameters Min. neg.-seq. current I2 and Min. neg.-seq. voltage V2).

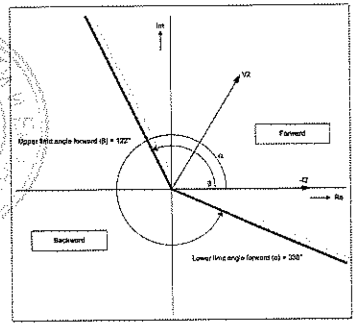

Figure 6-152 Phasor Diagram for Direction Determination with Negative-Sequence System Values

If the device determines a fault in the voltage-transformer secondary circuit (through the binary input voltage transformer circuit-breaker dropout or through measuring-voltage failure detection), direction determination will be disabled and every directionally set stage will be blocked. Non directionally set stages become active again if there are faults in the voltage transformer secondary circuit.

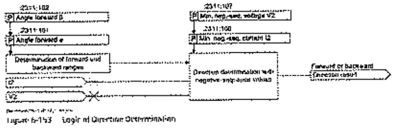

Figure 6-153 Logic of Direction Determination

Directional Mode

You use the Directional mode parameter to define whether the stage works in a forward or reverse direction. Non-directional operation is also possible.

Blocking the Tripping by Pickup of the Main Protection Functions

The pickup and type of pickup for the main protection functions can block the tripping of the stage. You can perform this setting via 2 parameters:

- Blocking by
  This setting is used to select the zone or stage at which blocking is to occur in the event of pickup.
- Blocking by prot. pickup
  The pickup type at which the blocking is to occur is defined with this parameter. The blocking can occur at any pickup or only at 1-pole or only at multipole pickups.
  The parameter is also used to set that no blocking should occur when the main protection has picked up.

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

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

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.

6.18.4 Application and Setting Notes for Direction Determination

Parameter: Limit Angle Region Forward

- Recommended setting value (_:2311:101) Angle forward α = 338°
- Recommended setting value (_:2311:102) Angle forward β = 122°

With the parameters Angle forward α and Angle forward β, you can change the location of the directional characteristic curve.

Siemens recommends using the defaults, because the function with these settings reliably determines the direction.

Parameter: Minimum Negative-Sequence System Variables V2 and I2

- Default setting (_:2311:107) Min. neg.-seq. voltage V2 = 0.7 V
- Default setting (_:2311:106) Min. neg.-seq. current I2 = 0.05 A

With the parameters Min. neg.-seq. voltage V2 and Min. neg.-seq. current I2, you can specify the minimum negative-sequence system values for direction determination with V2 and I2. The set limiting values must not be exceeded by operational unbalances.

6.18.5 Application and Setting Notes for Stages

Parameter: Directional mode

- Default setting (_:8101:114) Directional mode = forward

You use the Directional mode parameter to define the directional mode of the stage.

Parameter Value	Description
non-directional	If the stage is to work in the forward and reverse direction (in the direction of the line and busbar), then select this setting. The stage will work with this setting even if no directional measurement is possible, for example due to insufficient polarization voltage (or none at all), or due to failure of the measuring voltage.

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Parameter Value	Description
forward	Select these settings if the stage is only to work in a forward direction (in direction of the line).
reverse	Select this setting if the level is only to work in the reverse direction (in the direction of the busbar).

Parameter: Blk. w. inrush curr. detect.

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

- Default setting (_:8101:116) Blk. w. inrush curr. detect. = no

Parameter Value	Description
no	The transformer inrush-current detection does not affect the stage. Select this setting in the following cases: 1) In cases where the device is not used on transformers. 2) In cases where the device is used on transformers and the threshold value of the stage is set above the maximum inrush current of the transformer.
yes	When the transformer inrush current detection detects an inrush current that can lead to a tripping of the stage, the start of the time delay and tripping of the stage are blocked. Select this setting if the device is used on transformers and the threshold value of the stage is set below the maximum inrush current of the transformer.

Parameter: Blocking by the main Protection

- Recommended setting value (_:8101:140) Blocking by =

If you wish to give selective fault clarification through the main protection function precedence over tripping through the directional negative-sequence protection, you can define this via the 2 parameters Blocking by and Blocking by prot. pickup. The Blocking by parameter is used to select the zones or tripping stages of the main protection function(s), upon whose pickup the negative-sequence protection is to be blocked.

Parameter: Blocking by prot. pickup

- Default setting (_:8101:130) Blocking by prot. pickup = every pickup

The Blocking by prot. pickup parameter can be used to define the type of pickup, which leads to the blocking.

Parameter Value	Description
every pickup	Blocking at every pickup
1-phase pickup	Blocking only at 1-pole pickup
multi-phase pickup	Blocking only at multipole pickup
no pickup	If the pickup of the main protection function should not lead to blocking of the negative-sequence protection, select this setting.

Parameter: Hold mode 1-p dead time

- Default setting (_:8101:112) Hold mode 1p dead time = 0.040 s

The Hold mode 1p dead time setting is used to define the time by which the device internal signal for the 1-pole interruption is extended after the end of the 1-pole interruption.

At all line ends, there is no simultaneous switch-in after a 1-pole dead time. Thus, the parameterized operating mode for a 1-pole dead time must be retained for a certain time after the switch-in (end of the 1-pole dead time) until the other end or ends have securely switched in. The time to be set here corresponds to the maximum time between the switch-in of the 1st circuit breaker and the switch-in of the last circuit breaker at all ends of the feeder after a 1-pole dead time.

NOTE

The Hold mode 1p dead time setting is only available in devices with 1-/3-pole tripping. In devices with 3-pole tripping, this setting does not apply.

Parameter: Stabiliz. w. phase current

- Recommended setting value (_:8101:111) Stabiliz. w. phase current = 10 %

In order to avoid unwanted pickups and tripping, the negative-sequence system current stage is stabilized with the phase currents.

More information can be found in chapter 6.18.3 Function Description.

The threshold value increases as the phase currents increase.

You can change the stabilization factor (= gradient) via the Stabiliz. w. phase current parameter.

Siemens recommends a default setting of 10 % under normal operations.

Parameter: Threshold

- Default setting (_:8101:3) Threshold = 1.5 A

Define the pickup value corresponding to the application. In doing so, for the time-graded stages, the setting for the superordinate and subordinate stages must be taken into account in the grading chart.

With a very sensitive setting, you must make sure that the negative-sequence system current does not lead to undesired response of the stage due to unbalance (for example non-twisted line).

Parameter: Operate delay

- Default setting (_:8101:6) Operate delay = 0.30 s

The tripping delay (time delay) to be set is derived from the time grading schedule that has been prepared for the system.

When selecting the current and time setting, pay attention to whether the stage must work dependent on the direction.

6.18.6 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Angle forward α		0 ° to 360 °	338 °
_:2311:102	General:Angle forward β		0 ° to 360 °	122 °
_:2311:107	General:Min. neg.-seq. voltage V2		0.150 V to 34.000 V	1.233 V
_:2311:106	General:Min. neg.-seq. current I2	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				
_:8101:1	Definite-T 1:Mode		• off • on • test	off
_:8101:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:8101:114	Definite-T 1:Directional mode		• non-directional • forward • reverse	forward
_:8101:111	Definite-T 1:Stabiliz. w. phase current		0 % to 30 %	10 %
_:8101:3	Definite-T 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 100 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.500 A
		5 A @ 50 Irated	0.15 A to 175.00 A	7.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	7.500 A
_:8101:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	0.30 s
_:8101:116	Definite-T 1:Blk. w. inrush curr. detect.		• no • yes	no
_:8101:130	Definite-T 1:Blocking by prot. pickup		• every pickup • 1-phase pickup • multi phase pickup • no pickup	every pickup
_:8101:129	Definite-T 1:Op.mode at 1p dead time		• blocked • non-directional	blocked
_:8101:112	Definite-T 1:Hold mode 1p dead time		0.000 s to 60.000 s	0.040 s
_:8101:140	Definite-T 1:Blocking by		Setting options depend on configuration	

6.18.7 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>Test of direction	SPS	I
_:2311:300	General:Test direction	ACD	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:8101:81	Definite-T 1:>Block stage	SPS	I
_:8101:54	Definite-T 1:Inactive	SPS	O
_:8101:52	Definite-T 1:Behavior	ENS	O
_:8101:53	Definite-T 1:Health	ENS	O
_:8101:60	Definite-T 1:Inrush blocks operate	ACT	O
_:8101:302	Definite-T 1:Prot.PU blocks operate	SPS	O
_:8101:301	Definite-T 1:Mode 1p dead-tm.active	SPS	O
_:8101:55	Definite-T 1:Pickup	ACD	O
_:8101:56	Definite-T 1:Operate delay expired	ACT	O
_:8101:57	Definite-T 1:Operate	ACT	O

6.19 Thermal Overload Protection, 3-Phase

6.19.1 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

6.19.2 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.

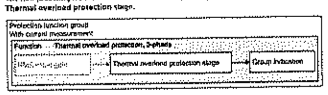

Figure 6-154 Structure/Embedding of the Function

6.19.3 Filter for RMS Value Gain

6.19.3.1 Description

The function block Filter can be used to adapt the RMS value for 2 means:

- To gain harmonics in a defined way. Higher harmonics can stress the protected object thermally more than lower harmonics. This is the case for reactors applied in AC filters. In addition, the amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically compensated by the filter
- To only compensate the amplitude attenuation of higher frequencies by the device (due to the anti-aliasing filter)

The filter gain (amplitude response) is realized by a 9 order FIR filter.

Logic

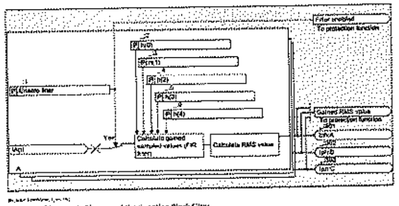

Figure 6-155 Logic Diagram of the Function Block Filter

The FIR filter gains the 8-kHz sampled values according to the set filter coefficients. Afterwards the RMS value is calculated. The symmetrical 9-order filter coefficients are set via the respective parameters h(0), h(1), h(2), h(3) and h(4).

NOTE

A FIR filter configuration tool is provided as an auxiliary PC tool. With this PC tool, the coefficients h(0), h(1), h(2), h(3), h(4) of the FIR filter are generated according to the required gain factors (amplitude response). The tool can be obtained from the SIPROTEC download area. For more information about the tool, refer to the tool help function.

The gained RMS value is delivered to the protection stages only when the function block Filter is instantiated and the parameter Enable filter is set as yes. Otherwise, the normal RMS value is used.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
Iph:A	Filtered RMS measured value of current A	kA	A	Parameter Rated current
Iph:B	Filtered RMS measured value of current B	kA	A	Parameter Rated current
Iph:C	Filtered RMS measured value of current C	kA	A	Parameter Rated current

You can find the parameter Rated current in the FB General of function groups where the Thermal overload protection function is used.

If the parameter Enable filter is set to no, the function values are shown as ---.

6.19.3.2 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 values of the coefficients, the filter has no effect and no gain is applied.

If the filter shall be applied to adapt the RMS value calculation to a specific protection object such as a reactor, the reactor manufacturer has to provide the required amplitude response (gain factors) for the reactor. To determine the coefficients h(0) to h(4) for the FIR filter, you must enter the gain factors into the auxiliary PC tool which is available in the SIPROTEC download area. The 5 required coefficients are generated by the tool. They have to be entered manually as settings to configure the filter. The amplitude attenuation of higher frequencies due to the anti-aliasing filter of the device is automatically taken into account and compensated by the filter.

To only compensate the attenuation of higher frequencies by the device, set the following coefficients in the filter.

Rated Frequency	Filter Coefficients for Only Compensating the Device Amplitude Attenuation
50 Hz	h(0) = -0.002 h(1) = -0.012 h(2) = 0.045 h(3) = 0.110 h(4) = 1.151
60 Hz	h(0) = 0.005 h(1) = 0.020 h(2) = 0.058 h(3) = -0.128 h(4) = 1.170

6.19.3.3 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

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6.19.3.4 Information List

No.	Information	Data Class (Type)	Type
Filter			
_:301	Filter:IphA	MV	O
_:302	Filter:IphB	MV	O
_:303	Filter:IphC	MV	O

6.19.4 Stage with Thermal Overload Protection

6.19.4.1 Description

Logic

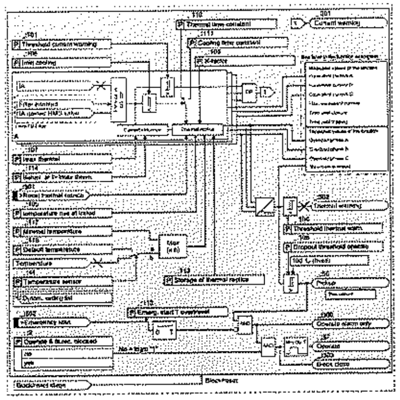

Figure 6-156 Logic Diagram of the Thermal Overload Protection Stage

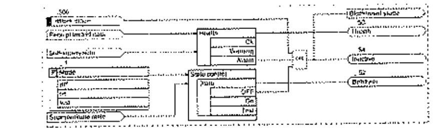

Figure 6-157 Logic Diagram of the Stage Control

RMS-Value Selection

The protection function supports 2 kinds of RMS measurement:

- Normal RMS value
- Gained RMS value from the function block Filter

The gained RMS value is automatically used if the function block Filter is configured and the filter has been enabled.

> **NOTE**
> When the function block Filter is applied, only one current measuring point I-3ph is allowed to be connected to the 3-phase current interface of the function group.

Thermal Replica

The protection function calculates the overtemperature from the phase currents based on a thermal single-body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th}\frac{d\theta}{dt} + \theta - \theta_{Amb}$$

With the following standardization:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{K \cdot I_{rated,obj.}} \qquad \theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{K^2 \cdot \Delta\vartheta_{rated,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \theta_{Amb} = \frac{\vartheta_{Amb} - 40\,°C}{\vartheta_{max}} = \frac{\vartheta_{Amb} - 40\,°C}{K^2 \cdot \Delta\vartheta_{Amb,obj.}}$$

θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current $k \cdot I_{rated,obj}$
θ_{Amb}	Standardized ambient temperature, where ϑ_{Amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{Amb} can be the measured ambient temperature or the ambient temperature preset using the Default temperature parameter.
$\Delta\vartheta_{rated,obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object

k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated,obj}$)
$I_{rated,obj}$	Rated current of the protected object

At the same time, $I_{rated,obj}$ is the rated current of the assigned protected object side:

- In the case of transformers, the rated current of the winding to be protected, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- The uncontrolled winding forms the basis in the case of transformers with voltage control.
- In the case of generators, motors and reactors, the rated current, which the device calculates from the set rated apparent power and rated voltage, is decisive.
- In the case of lines, nodes and busbars, the rated current of the protected object is set directly.

In a steady state, the solution to the thermal differential equation is an e-function whose asymptote represents the final overtemperature Θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (Threshold thermal warn.), a warning indication is given.

If the overtemperature limit Θ_{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 6-158 shows the temperature rise at different overload currents and the supervision thresholds.

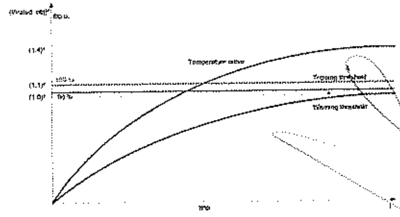

Figure 6-158 Temperature History for Different Overload Currents (K-factor = 1.1)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

If the flowing current falls below an adjustable minimum current Imin cooling , the Cooling time constant is activated.

Operate Curve

If the ambient temperature is not measured and set to 40°C, you can get the operate curve as following:

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

t	Operate time
τ_{th}	Time constant
I	Measured load current
$I_{preload}$	Preload current
k	Setting factor according to VDE 0435 part 3011 or IEC 60255-8 (K factor)
$I_{rated,obj}$	Rated current of the protected object

Ambient Temperature

This function can take the ambient temperature into consideration. The reference temperature of the thermal model is 40°C. If the ambient temperature drops below the reference temperature, the thermal limit increases, the equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The Default temperature parameter can be used to fix or measure the ambient temperature. The Minimal temperature parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter Temperature rise at Irated).

The measured ambient temperature is measured by an external RTD unit (RTD = Resistance Temperature Detector) and provided by the functions RTD unit Ether. or RTD unit serial of the function group Analog transformer. When using the Temperature sensor parameter, the respective temperature sensor can be selected.

If the temperature measurement is faulty, for example, due to an open circuit between the device and the RTD unit, the device reports this. In this case, the process continues with either the temperature measured last or the value set under the Default temperature parameter, depending on which value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuit, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding $I_{2 \cdot limit}$). 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 canceled 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 setting parameter Storage of thermal replica . You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Map

You can reset the thermal memory via the binary input indication >Reset thermal replica . The thermal memory will then have a 0 value. A reparameterization will also lead to resetting the thermal memory.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal >Emergency start , tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input >Emergency start disappears, the blocking remains in effect for the set Emerg. start T overtravel .

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal >Block stage .

All indications then drop out and the thermal memory is set to the value 0.

Blocking Closure

The signal Block close can be used to prevent closure of the protected object at a high thermal load. The signal is set if the tripping overtemperature is exceeded, and cancelled if the temperature falls below the dropout threshold.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

6.19.4.2 Application and Setting Notes

Parameter: Threshold current warning

- Recommended setting value (_:101) Threshold current warning = 1.1 A at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max,perm}$). This results in the same setting value as for the K-factor .

Parameter: Threshold thermal warn.

- Recommended setting value (_:104) Threshold thermal warn. = 90 %

The default setting can be left at a K-factor of 1.1, as the thermal memory results for 83 % at continuously flowing rated current. The calculation uses the rule of three: 100 % corresponds to (K-factor)^2 and x % corresponds to 1^2.

$$\frac{\Theta}{\Theta_{trip}} = \frac{100\,\%}{k^2} = 83\,\%$$

At a K-factor of 1.05, the thermal memory for rated current is already 91 % filled. Increase the Threshold thermal warn. to 95 %.

Parameter: Dropout threshold operate

- Recommended setting value (_:105) Dropout threshold operate = 90 %

The Dropout threshold operate parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling or longer blocking of closing.

Note that the calculation of the operational measured value Time until close refers to this value.

Parameter: Emerg. start T overtravel

- Default setting (_:112) Emerg. start T overtravel = 6300 s

This functionality is not required for protection of lines and cables. If the logical binary indication is not routed, the Emerg. start T overtravel will be ineffective. The Emerg. start T overtravel presetting can therefore be retained.

Parameter: K-factor

- Recommended setting value (_:106) K-factor = 1.1

The K-factor parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated,obj}$ of the protected object (for example, cable) is the basic current for overload sensing. You can determine the K-factor on the basis of the thermally permissible continuous current $I_{max,perm}$:

$$K\text{-factor} = \frac{I_{max,perm}}{I_{rated,obj}}$$

> **NOTE**
> The thermally permissible continuous current for the protected object is known from relevant tables or from the specifications of the manufacturer.

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In the case of cables, the permissible continuous current depends on the cross section, insulation material, design type, and the manner in which the cables have been laid. In the case of overhead lines, an overload of 10 % is permissible.

EXAMPLE

For the Permissible Continuous Current
Cross-linked polyethylene cables (N2XS2Y): 10 kV 150 mm² (Cu)
Current-carrying capacity (underground laying): $I_{perm,cont}$ = 406 A
Selected K factor of 1.1
This yields a rated current of $I_{rated,obj}$ = 369 A

Parameter: Thermal time constant

- Recommended setting value (_:110) Thermal time constant = 2777 s (46.29 min)

The Thermal time constant parameter is used to define the tripping characteristic of the stage. If no data on the Thermal time constant is available, you can determine this from the short-time current-rating capacity of the cable, for example, from the 1 s current. The 1 s current is the maximum current permissible for 1 s application time. The 1 s current can be found in the cable specifications. Calculate the Thermal time constant according to the following formula:

$$\tau[min] = \frac{1}{60}\left(\frac{\text{perm. 1-s-current}}{\text{perm. continuous current}}\right)^2$$

If the short-term current rating capacity is specified for an application time other than 1 s, use the short-time current instead of the 1 s current. Multiply the result by the specified application time.
For a given short-term current-carrying capacity of 0.5 s, use the following formula:

$$\tau[min] = \frac{0.5}{60}\left(\frac{\text{perm. 0.5-s-current}}{\text{perm. continuous current}}\right)^2$$

EXAMPLE for a Cable

For a cable:
Permissible continuous current $I_{perm,cont}$ = 406 A
Maximum short-circuit current for 1 s I_{1s} = 21.4 kA
Therefore, for the Thermal time constant, it follows:

$$\tau[min] = \frac{1}{60}\left(\frac{21400\ A}{406\ A}\right)^2 = \frac{1}{60}\cdot 52.7^2 = 46.29\ min$$

with 46.29 min = 2777 s

Parameter: Cooling time constant

- Recommended setting value (_:111) Cooling time constant = 2777 s

The Cooling time constant parameter is used to define the dropout behavior of the stage. Cables and overhead lines have the same time constant for both heating and cooling. Therefore, set the same value for the Cooling time constant as for the parameter Thermal time constant.

Parameter: Imax thermal

- Recommended setting value (_:107) Imax thermal = 2.5 A at I_{rated} = 1 A

The Imax thermal parameter allows you to set the threshold current for the Behav. at I> Imax therm. parameter. The selected threshold current of 2.5 $I_{rated,sec}$ is a practicable value.

Parameter: Imin cooling

- Recommended setting value (_:108) Imin cooling = 0 A

If only the thermal time constant (parameter Thermal time constant) must provide protection, set the current parameter Imin cooling to 0 A.

Parameter: Temperature rise at Irated

- Default setting (_:109) Temperature rise at Irated = 70 K

As a value, set the overtemperature that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the technical data of the equipment or measure it. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature or the coolant temperature from the measured value.
When selecting the setting value, you can also use the specified temperature class for orientation. Usually, you will find the overtemperature expressed in Kelvin (K), which can be accepted as is. If the absolute temperature is given, the ambient temperature must be deducted. As a rule, this is 40°C.
The overtemperature at maximum permissible current (Δmax) and the Temperature rise at Irated (Δrated,obj.) can be converted by using the following formula:

$$k^2 = \left(\frac{\Delta\Theta_{max}}{\Delta\Theta_{rated,obj.}}\right)$$

EXAMPLE:

Temperature class B for continuous operation: permissible overtemperature = 80 K
From this, a temperature for I_{rated} of 120°C (80 K + 40°C) can be derived when using a temperature sensor for the measurement.
Temperature class F at thermal limiting value: permissible overtemperature = 105 K.
From this, a maximum temperature of 145°C (105 K + 40°C) derives.
From these values, the K factor can be derived:

$$k^2 = \frac{\Delta\Theta_{max,perm.}}{\Delta\Theta_{rated,obj.}} = \frac{105\ K}{80\ K} = 1.31 \quad \rightarrow k = 1.146$$

If you select a setting value of 1.1 for the K-factor, your selection can be considered as conservative.

NOTE
For electrical machines, the limits can vary depending on the type of coolant.
Consult the machine manufacturer to agree on a setting value for the overtemperature.

Parameter: Storage of thermal replica

- Recommended setting value (_:113) Storage of thermal replica = no

If a continuous auxiliary voltage for the bay units is ensured, the bay default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value (_:114) Behav. at I> Imax therm. = freeze therm. rep.

The Behav. at I> Imax therm. parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified.
The default setting has been selected to be compatible with SIPROTEC 4 devices. If you wish to take further temperature rise into consideration, the current limiting procedure is recommended.

Parameter Value	Description
freeze therm. rep.	If input currents exceed the Imax thermal parameter, the thermal replica will be frozen for the time the parameter is exceeded. This parameter value is provided to enable compatibility with older products!
current limiting	The input currents are limited to the value set in the Imax thermal parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated,sec}$

Parameter: Temperature sensor

- Default value (_:44) Temperature sensor = none

With the Temperature sensor parameter, you determine which temperature sensor to use to detect the ambient temperature.
A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and feed it to the device via an RTD unit. The Thermal overload protection function receives the measured temperature value via the functions RTD unit Ether. or RTD unit Serial from the function group Analog transformer.

Parameter: Default temperature

- Recommended setting value (_:118) Default temperature = 40°C

The Default temperature is set as ambient temperature under the following conditions:

- No temperature sensor for measuring the ambient temperature is connected.
- The temperature measurement is faulty and the last measured temperature value is less than the Default temperature.

Siemens recommends using the default setting.

Parameter: Minimal temperature

- Default setting (_:117) Minimal temperature = -20°C

If the measured ambient temperature drops below the set value, the set value is assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and this temperature drops below the value set in the Minimal temperature parameter, the Minimal temperature is also used.

6.19.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:112	49 Th.overl. #:Emerg. start T overtravel		0 s to 15000 s	300 s
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:111	49 Th.overl. #:Cooling time constant		10 s to 60000 s	3600 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	7.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:108	49 Th.overl. #:Imin cooling	1 A @ 100 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.000 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.00 A to 50.00 A	2.50 A
		1 A @ 1.6 Irated	0.000 A to 1.600 A	0.500 A
		5 A @ 1.6 Irated	0.000 A to 8.000 A	2.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:118	49 Th.overl. #:Default temperature		-55°C to 55°C	40°C
_:117	49 Th.overl. #:Minimal temperature		-55°C to 40°C	-20°C
_:44	49 Th.overl. #:Temperature sensor		Setting options depend on configuration	

6.19.4.4 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
_:502	49 Th.overl. #:>Emergency start	SPS	I

No.	Information	Data Class (Type)	Type
_:54	49 Th.overl. #:Inactive	SPS	O
_:52	49 Th.overl. #:Behavior	ENS	O
_:53	49 Th.overl. #:Health	ENS	O
_:301	49 Th.overl. #:Current warning	SPS	O
_:302	49 Th.overl. #:Thermal warning	SPS	O
_:303	49 Th.overl. #:Block close	SPS	O
_:55	49 Th.overl. #:Pickup	ACD	O
_:300	49 Th.overl. #:Operate alarm only	ACT	O
_:57	49 Th.overl. #:Operate	ACT	O
_:304	49 Th.overl. #:Time until close	MV	O
_:305	49 Th.overl. #:Time until trip	MV	O
_:306	49 Th.overl. #:Overload phase A	MV	O
_:307	49 Th.overl. #:Overload phase B	MV	O
_:308	49 Th.overl. #:Overload phase C	MV	O
_:309	49 Th.overl. #:Overload maximum	MV	O
_:310	49 Th.overl. #:Equival. current phs A	MV	O
_:311	49 Th.overl. #:Equival. current phs B	MV	O
_:312	49 Th.overl. #:Equival. current phs C	MV	O
_:313	49 Th.overl. #:Equival. current max.	MV	O

6.20 Thermal Overload Protection, User-Defined Characteristic Curve

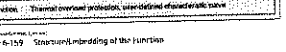
6.20.1 Overview of Functions

The Thermal overload protection, user-defined characteristic curve function (ANSI 49) is used to:

- Protect the equipment (motors, generators, and transformers) against thermal overloads
- Realize a manufacturer-specific overload characteristic curve for specific equipment, for example, shunt reactors
- Monitor the thermal state of motors, generators, and transformers

6.20.2 Structure of the Function

The Thermal overload protection, user-defined characteristic curve function is used in protection function groups with 3-phase current measurement.
The Thermal overload protection, user-defined characteristic curve function is preconfigured.



[illegible]
Figure 6-159 Structure/Embedding of the Function

ВЯРНО С ОРИГИНАЛА

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6.20.3 Function Description

Logic

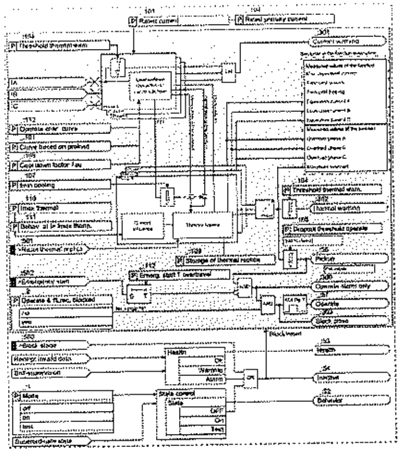

Figure 6-160 Logic Diagram of the Thermal Overload Protection, User-Defined Characteristic Curve Function

(1) The (_:101) Rated current parameter is from the protected object.

(2) The (_:104) Rated primary current parameter is from the used current transformer.

User-Defined Characteristic Curve

For specific equipment (for example, shunt reactors and transformers) or for special applications, the manufacturer specifies an overload characteristic curve. This curve cannot be described accurately with a single-

body model so that deviations can occur. The following figure shows an example of a predefined overload characteristic curve and 2 standard characteristic curves based on the single body model.

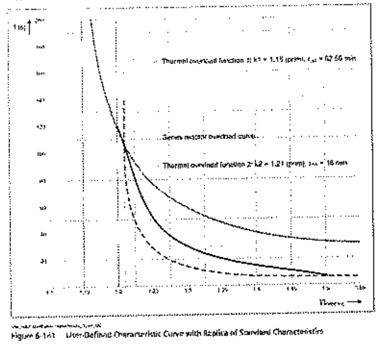

Figure 6-161 User-Defined Characteristic Curve with Replica of Standard Characteristics

The calculation is identical to the realization of the standard Thermal overload protection, 3-phase function. You can find more information in the function description Thermal overload protection, 3-phase starting from chapter 6.19.1 Overview of Functions.

The main deviations are as follows:

- The thermal characteristic is set with a flexible characteristic ($t_{op} = f(I/I_{rated,obj})$).
  - The first point of the characteristic curve is important and is used to calculate the internal k-factor.
  - The point at $I/I_{rated,obj}$ = 1.5 is used to calculate the internal thermal time constant. If there is no point at $I/I_{rated,obj}$ = 1.5, the point which is the closest to $I/I_{rated,obj}$ = 1.5 from $I/I_{rated,obj}$ = 1.1 is used to calculate the internal thermal time.
  - The points are set according to the maximum permissible load current.
- The Curve based on preload parameter describes for which thermal preload the user-defined characteristic curve is valid. Normally, such a curve is given for protected objects under rated load.
- The Cool-down factor Tau parameter is used for the determination of the cooling time constant. The set factor is multiplied with the internal calculated time constant.
- The thermal model is based on a constant ambient temperature of 40 °C. It cannot be corrected via the external measurement.

Thermal Replica

The protection function calculates the overtemperature from the phase currents on the basis of a thermal single body model according to the thermal differential equation with

$$I_{p.u.}^2 = \tau_{th} \cdot \frac{d\theta}{dt} + \theta$$

With the following standardizations:

$$I_{p.u.} = \frac{I}{I_{max}} = \frac{I}{k \cdot I_{rated,obj.}} \qquad \theta = \frac{\vartheta}{\vartheta_{max}} = \frac{\vartheta}{k^2 \cdot \Delta\vartheta_{rated,obj.}}$$

$$\tau_{th} = R_{th} \cdot C_{th}$$

θ	Current overtemperature, in relation to the final temperature at a maximum permissible phase current $k \cdot I_{rated,obj}$
$\Delta\vartheta_{rated,obj}$	Overtemperature of the protected object set at rated current
τ_{th}	Thermal time constant (temperature rise/cooling) of the protected object. The value is calculated internally.
k	This factor indicates the maximum continuous permissible phase current. The factor refers to the rated current of the protected object ($k = I_{max}/I_{rated,obj}$) and is calculated internally.
$I_{rated,obj}$	Rated current of the protected object

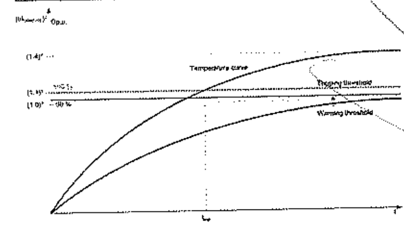

Figure 6-162 Temperature History for Different Overload Currents (K-factor = 1.1)

The overtemperature is calculated separately for each phase. The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached. The maximum overtemperature of the phases is regarded as the tripping temperature. This means that the highest of the 3 phase currents is always assumed.

The analysis of the RMS values of the currents over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Current Influence

The thermal replica based on the single-body model applies only with limitations to high overcurrent situations (short circuits, motor startup currents). To avoid an overfunction of the overload protection, the thermal replica must be influenced in case of overcurrents (exceeding $I_{max,therm}$). 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 can be avoided. If the first setting value of the user-defined characteristic curve is set to 1.1 of the rated current, a thermal memory value of 83 % is set to the 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 setting parameter Storage of thermal replica. You can save the thermal state for a time of 500 min. Once the supply voltage returns, the thermal replica continues to function with the saved thermal state.

If the thermal replica is not saved, it will be reset to 0 upon failure of the auxiliary voltage.

Resetting the Thermal Memory

You can reset the thermal memory via the binary input indication >Reset thermal replica. The thermal memory will then have a 0 value.

Emergency Start

Depending on the operating conditions, tripping can be blocked or closure enabled despite the permissible thermal limits being exceeded. Upon activation of the binary input signal >Emergency start, tripping is blocked and closure enabled. This does not affect the state of the thermal memory. After the input >Emergency start disappears, the blocking remains in effect for the set Emerg. start T overtravel.

Blocking the Function

Blocking will cause a picked up function to be reset. The tripping function can be blocked externally or internally by the binary input signal >Block stage.

All indications then drop out and the thermal memory is not calculated.

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

Values	Description	Primary	Secondary	% Referenced to
(_:601:305) Time until trip	Expected time until tripping	s	s	s
(_:601:304) Time until close	Time until close release	s	s	s
(_:601:306) Overload phase A	Thermal measured values of the phases	%	%	Tripping temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured value of the overload protection	%	%	Tripping temperature
(_:601:310) Equival. current phs A	Current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value which serves as basis for the overload measured value	A	A	Rated operating current of the primary values

6.20.4 Application and Setting Notes

Motors and generators as well as transformers are at risk from long-lasting overloads. You can adapt the given overload characteristic curve to the user-defined characteristic curve with the Thermal overload protection, user-defined characteristic curve function. You can find the predefined characteristic curve in the chapter 12.27 Thermal Overload Protection, User-Defined Characteristic Curve.

When setting the parameters, consider the following:

- The settings for the used current transformer (primary values and secondary values) must be set correctly in the power system.
- The rated values for the protected object must be correct in the used function group.

Parameter: Threshold current warning

- Recommended setting value (_:103) Threshold current warning = 1.1 A at I_{rated} = 1 A

Set the threshold to the maximum permissible continuous current ($I_{max,perm}$). This results in the same setting value as for the first value of the user-defined characteristic curve.

Parameter: Threshold thermal warn.

- Recommended setting value (_:104) Threshold thermal warn. = 90 %

If the first value of the user-defined characteristic curve is 1.1 of the rated current, the default setting can be left. The thermal memory results for 83 % at continuously flowing rated object current.

If the first value of the user-defined characteristic curve is 1.05 of the rated object current, the thermal memory for rated current is already 91 % filled. Increase the Threshold thermal warn. to 95 %.

Parameter: Dropout threshold operate

- Recommended setting value (_:105) Dropout threshold operate = 90 %

The Dropout threshold operate parameter is used to drop out pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling or longer blocking of closing.

Note that the calculation of the operational measured value Time until close refers to this value.

Parameter: Emerg. start T overtravel

- Default setting (_:112) Emerg. start T overtravel = 300 s

The Emerg. start T overtravel parameter is used to set the time for which blocking of the tripping has to remain active after an outgoing binary input signal >Emergency start. With an outgoing input signal, the load on the protected object is removed. The emergency start T-overtravel must be set long enough to allow the thermal memory to fall below the dropout threshold after cooling. Select a time on the order of magnitude of the Cooling time constant. In the example, 5 min (300 s) have been assumed.

Parameter: Imax thermal

- Recommended setting value (_:107) Imax thermal = 2.5 A at I_{rated} = 1 A

The Imax thermal parameter allows you to set the threshold current for the Behav. at I> Imax therm. parameter. If you calculate with relatively long start times for motors (longer than 25 s), the current limiting must be reduced to 2 $I/I_{rated,obj}$.

Parameter: Imin cooling

- Recommended setting value (_:108) Imin cooling = 0.5 A at I_{rated} = 1 A

When defining the minimum current Imin cooling, you can use the no-load current for orientation. If no data is available, set 0.5 $I/I_{rated,obj}$. If the current falls below this value, the internal thermal time constant is automatically switches to the internal cooling time constant with the Cool-down factor Tau parameter.

Parameter: Storage of thermal replica

- Recommended setting value (_:113) Storage of thermal replica = no

If a continuous auxiliary voltage for the bay units is ensured, the default setting can be retained.

Parameter: Behav. at I> Imax therm.

- Recommended setting value (_:114) Behav. at I> Imax therm. = current limiting

The Behav. at I> Imax therm. parameter is used to select the process by which the function reacts to short-circuit currents. To prevent premature tripping of the overload protection at low time constants, high preloading and high short-circuit currents, the thermal replica can be modified. As overcurrent due to a starting of the motor also leads to a certain heating of the stator winding, limiting the input current is recommended for machines.

Parameter Value	Description
current limiting	The input currents are limited to the value set in the Imax thermal parameter. If the measured current exceeds the set current value, the limited current value is supplied to the thermal replica. An advisable current threshold is approx. 2 to 2.5 $I_{rated,obj}$
freeze therm. rep.	If input currents exceed the Imax thermal parameter, the thermal replica will be frozen for the time the parameter is exceeded.

Parameter: Curve based on preload

- Default value (_:101) Curve based on preload = 100 %

The Curve based on preload parameter is used for a certain load case. In most cases, it applies for an operation under rated conditions. For that, it is assumed that rated current is flowing permanently. This is referred to as warm condition. In this case, the default setting 100 % is applied.

Thus, the thermal behavior is also correct for different preloads.

For cases without preload or cold condition, set the parameter to 0 %.

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Parameter: Cool-down factor Tau

- Default value (_:108) Cool-down factor Tau = 7.0

If the current becomes lower than the setting value of the Imin cooling parameter, you can set the Cool-down factor Tau parameter to calculate the internal cooling time constant.

Parameter: Operate char. curve

- Default value Operate char. curve = 1.1 p.u., 600.00 s

With the Operate char. curve parameter, you define the characteristic curve in a tabular form with ordered normalized current values and associated normalized time values.

When setting the parameter, consider the following:

- Set the current value as per-unit value with the rated current of the protected object as reference.
- Set the time value in seconds.
- Enter the values in continuous order.

EXAMPLE

With the following 12 points, you can get a user-defined characteristic curve as shown in the following figure.

Table 6-13 User-Defined Points

I/I_rat	t (s)
1.16	120.00
1.21	96.00
1.25	76.00
1.28	60.00
1.35	48.00
1.42	37.50
1.48	33.50
1.58	27.50
1.84	20.50
2.00	14.00
2.25	9.85
8.00	9.85

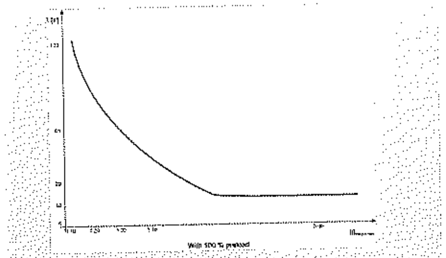

Figure 6-163 Example of the User-Defined Characteristic Curve

6.20.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User charact.#:Mode		• off • on • test	off
_:2	User charact.#:Operate & flt.rec. blocked		• no • yes	no
_:107	User charact.#: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	User charact.#:Threshold thermal warn.		50 % to 100 %	90 %
_:105	User charact.#:Dropout threshold operate		50 % to 99 %	90 %
_:106	User charact.#:Emerg. start T overtravel		0 s to 15000 s	300 s

Addr.	Parameter	C	Setting Options	Default Setting
_:107	User charact.#:Imin cooling	1 A @ 100 Irated	0.030 A to 10.000 A	0.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	2.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.500 A
		5 A @ 50 Irated	0.15 A to 50.00 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
_:108	User charact.#:Cool-down factor Tau		0.5 to 20.0	7.0
_:109	User charact.#:Storage of thermal replica		• no • yes	no
_:110	User charact.#: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
_:111	User charact.#:Behav. at I> Imax therm		• current limiting • freeze therm. rep.	current limiting
_:112	User charact.#:Operate char. curve		Setting options depend on configuration	1.1 p.u., 600 s
_:101	User charact.#:Curve based on preload		0 % to 100 %	100 %

6.20.6 Information List

No.	Information	Data Class (Type)	Type
User charact.#			
_:81	User charact.#:>Block stage	SPS	I
_:500	User charact.#:>Reset thermal replica	SPS	I
_:501	User charact.#:>Emergency start	SPS	I
_:54	User charact.#:Inactive	SPS	O
_:52	User charact.#:Behavior	ENS	O
_:53	User charact.#:Health	ENS	O
_:300	User charact.#:Current warning	SPS	O
_:301	User charact.#:Thermal warning	SPS	O
_:302	User charact.#:Block close	SPS	O
_:55	User charact.#:Pickup	ACD	O
_:303	User charact.#:Operate alarm only	ACT	O
_:57	User charact.#:Operate	ACT	O
_:304	User charact.#:Time until close	MV	O
_:305	User charact.#:Time until trip	MV	O
_:306	User charact.#:Overload phase A	MV	O
_:307	User charact.#:Overload phase B	MV	O
_:308	User charact.#:Overload phase C	MV	O
_:309	User charact.#:Overload maximum	MV	O
_:310	User charact.#:Equival. current phs A	MV	O
_:311	User charact.#:Equival. current phs B	MV	O

No.	Information	Data Class (Type)	Type
_:312	User charact.#:Equival. current phs C	MV	O
_:313	User charact.#:Equival. current max.	MV	O

6.21 Thermal Overload Protection, 1-Phase

6.21.1 Overview of Functions

The **Thermal overload protection 1-phase** function (ANSI 49) is used to:

- Protect the equipment (reactors or resistors in the neutral point of a transformer) from thermal overload

6.21.2 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 steplessly preconfigured.

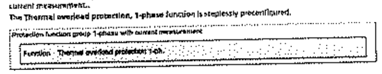

Figure 6-164 Structure/Embedding of the Function

6.21.3 Function Description

Logic

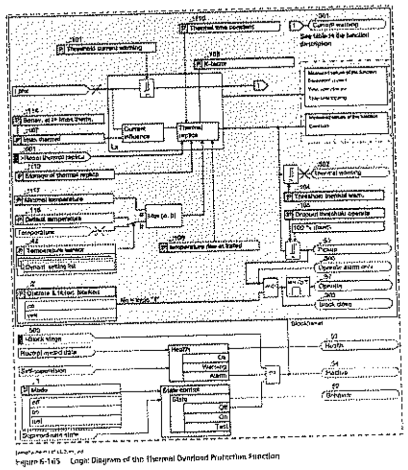

Figure 6-165 Logic Diagram of the Thermal Overload Protection Function

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

$$I_{eq}^2 = \tau_{th} \frac{d\Theta}{dt} + \Theta = \Theta_V$$

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With the following standardizations:

$$I_{\text{pu}} = \frac{I}{I_{\text{max}}} = \frac{I}{k \cdot I_{\text{rated obj}}} \qquad \Theta = \frac{\vartheta}{\vartheta_{\text{max}}} = \frac{\vartheta}{k^2 \cdot \Delta\vartheta_{\text{rated obj}}}$$

$$\tau_{th} = R_{th} \cdot C_{th} \qquad \Theta_{y} = \frac{\vartheta_{\text{amb}} - 40\,^{\circ}\text{C}}{\vartheta_{\text{max}}} = \frac{\vartheta_{\text{amb}} - 40\,^{\circ}\text{C}}{k^2 \cdot \Delta\vartheta_{\text{rated obj}}}$$

Θ	Current overtemperature, in relation to the final temperature at a maximum permissible current $k \cdot I_{\text{rated, obj}}$
Θ_y	Standardized ambient temperature, where ϑ_{amb} describes the coupled ambient temperature. The coupled ambient temperature ϑ_{amb} can be the measured ambient temperature or the ambient temperature preset using the Default temperature parameter.
$\Delta\vartheta_{\text{rated obj}}$	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 ($k = I_{max}/I_{rated,obj}$)
$I_{\text{rated, obj}}$	Rated current of the protected object

At the same time, $I_{\text{rated, obj}}$ is the rated current of the protected object.

In a steady state, the solution to the thermal differential equation is an e function whose asymptote represents the final overtemperature Θ_{end}. The time constant τ_{th} determines the rise. After reaching an initial adjustable overtemperature threshold Θ_{warn} (Threshold thermal warn.), a warning indication is given.

If the overtemperature limit Θ_{off} (tripping overtemperature) is exceeded, an operate indication is immediately issued and the equipment disconnected from the power supply. This threshold is specified at 100 % and corresponds to the final temperature set at a flowing permissible continuous current (I_{max}).

Figure 6-166 shows the temperature rise at different overload currents and the supervision thresholds.

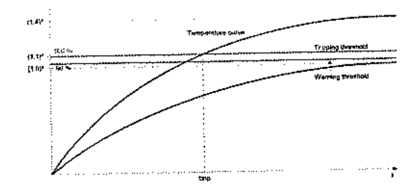


Figure 6-166 Temperature History for Different Overload Currents (K-factor = 1.1)

The current overtemperature can be obtained from the operational measured values. It is shown in percent. An indication of 100 % means that the thermal threshold has been reached.

The analysis of the RMS value of the current over a broad frequency band also includes the harmonic components. These harmonic components contribute to the temperature rise of the equipment.

Ambient Temperature

This function can take the ambient temperature into consideration. The reference temperature of the thermal model is 40 °C. If the ambient temperature drops below the reference temperature, the thermal limit increases. The equipment can be stressed more. If the ambient temperature is higher, the conditions change.

The Default temperature parameter can be used to fix or measure the ambient temperature. The Minimal temperature parameter limits the coupled ambient temperature. If the measured ambient temperature is lower than the minimum temperature, the minimum temperature is processed in the thermal model.

The ambient temperature refers to the overtemperature of the protected object, which sets itself at the rated current (parameter Temperature rise at Irated).

The measured ambient temperature is recorded by an external RTD unit (RTD = Resistance Temperature Detector) and provided by the functions RTD unit Ether. or RTD unit serial of the function group Analog units. When using the Temperature sensor parameter, the respective temperature sensor can be selected.

If the temperature measurement is disrupted, for example, due to an open circuit between the device and the RTD unit, the device will report it. In this case, the process continues with either the temperature measured last or the value set under the Default temperature parameter, whichever value is the highest.

Current Influence

The thermal replica based on the single-body model applies with limitations to high overcurrent situations (short circuits). To avoid an overfunction of the overload protection, the thermal replica must be influenced for overcurrents (exceeding I_{max}). You can select between 2 strategies for this:

- Freezing of the thermal memory
- Limitation of the input current for the thermal replica to the set current. The temperature rise is thereby retarded at high currents.

Warning Thresholds

The thermal warning threshold issues a warning indication before the tripping threshold (tripping temperature) is reached. In this way, for example, a load can be reduced in sufficient time and a disconnection avoided. At a normal K-factor of 1.1, a thermal memory value of 83 % sets in at continuously flowing rated current.

Apart from the thermal warning threshold, the overload protection also has a current-warning threshold. This current-warning threshold can signal an overload current in sufficient time before the overtemperature value has reached the warning or tripping threshold.

Dropout of Tripping

Once the thermal memory has fallen below the setting value of the Dropout threshold operate, the trip command is cancelled upon tripping. In contrast, the current-warning threshold and the thermal warning threshold are 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 canceled 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 issued as a thermal current-measured value (A or kA). The current equivalent is the primary current, which corresponds to the thermal measured value in percent, assuming steady-state conditions.
(_:304) Time until close	The Time until close is the expected time until it is possible for the protected object for reclosure. The calculation of this value is based on the assumption of constant currents. The thermal replica has then fallen below the setting value of the dropout threshold.
(_:305) Time until trip	The Time until trip is the expected time until tripping (100 % value exceeded) occurs. The calculation of this value is based on the assumption of constant currents.
(_:306) Overload	The value Overload indicates the current temperature of the protected object in percent. Tripping occurs if 100 % is exceeded.

6.21.4 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 ($I_{max, perm}$). 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.

$$\frac{\Theta}{\Theta_{off}} = \frac{100\,\%}{k^2} = 83\,\%$$

At a K-factor of 1.05, the thermal memory for rated current is 91% filled. Increase the Threshold thermal warn. to 95%.

Parameter: Dropout threshold operate

- Recommended setting value (_:105) Dropout threshold operate = 90 %

The Dropout threshold operate parameter is used to cancel pickup and tripping when the value drops below this threshold. A setting on the order of magnitude of the warning threshold is recommended. You can select a lower setting value for special applications, desired additional cooling, or longer blocking of switching on.

The calculation of the operational measured value Time until close refers to this value.

Parameter: K-factor

- Recommended setting value (_:106) K-factor = 1.1

The K-factor parameter is used to describe the limiting value for the maximum permissible continuous load. The rated current $I_{rated,obj}$ of the protected object (for example, resistance) is the basic current for overload sensing.

You can determine K-factor on the basis of the thermally permissible continuous current $I_{max, perm}$:

$$\text{K-factor} = \frac{I_{max,perm}}{I_{rated,obj}}$$

> **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:

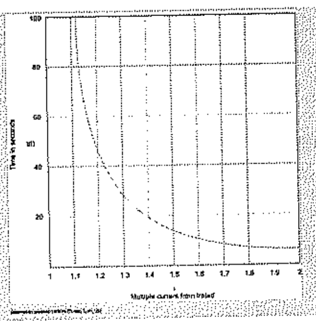
- 1.1 I_{rated} permanent (k-factor = 1.1; k = 1.1)
- 1.5 I_{rated} for 20 s for charge by cold

The following time constant results from these assumed values:

$$\tau_{th} = t \times \left[\ln\frac{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2}{\left(\frac{I}{k \cdot I_{rated,obj}}\right)^2 - 1}\right]^{-1} = 20\,s \times \left[\ln\frac{\left(\frac{1.5}{1.1}\right)^2}{\left(\frac{1.5}{1.1}\right)^2 - 1}\right]^{-1} = 20\,s \times \left[\ln\frac{1.86}{0.86}\right]^{-1} = 26\,s$$

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 occurs in 20 s.



Parameter: Imax thermal

- Recommended setting value (_:107) Imax thermal = 2.5 A for I_{rated} = 1 A

The Imax thermal parameter allows you to set the threshold current for the Behav. at I> Imax therm. parameter. The selected current threshold of 2.5 $I_{rated,obj}$ is a practicable value.

Parameter: Temperature rise at Irated

- Default setting (_:109) Temperature rise at Irated = 70 K

> **NOTE**
>
> For an application as a 1-phase overload protection, the ambient temperature measured via the temperature sensor is not taken into account. Therefore, the setting has no influence. You can keep the default setting. If you take into account the temperature, note the following descriptions.

Set the overtemperature as the value that is the result if the equipment is continuously operated with the rated current and at an ambient temperature of 40°C. Here, the rated current refers to the protected object. You can find the temperature value in the Technical data of the equipment or you can measure the value. If you use a temperature sensor when measuring at the rated current, deduct the actual ambient temperature 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:

$$k^2 = \left(\frac{\Delta\vartheta_{max}}{\Delta\vartheta_{rated,obj}}\right)$$

EXAMPLE:

Temperature class B for continuous operation: permissible overtemperature = 80 K

From this, a temperature for I_{rated} of 120 °C (80 K + 40 °C) can be derived when using a measuring element for the measurement.

Temperature class F as thermal limiting value: permissible overtemperature = 105 K.

From this, a maximum temperature of 145 °C (105 K + 40 °C) derives.

From these values, the magnitude of the K factor can also be derived:

$$k^2 = \frac{\Delta\vartheta_{max,perm}}{\Delta\vartheta_{rated,obj}} = \frac{105\,K}{80\,K} = 1.31 \quad \rightarrow k = 1.146$$

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 modified.

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 (_:44) Temperature sensor = none

Use the Temperature sensor parameter to determine which temperature sensor to use to detect the ambient temperature.

A temperature sensor (RTD = Resistance Temperature Detector) is used to measure the ambient temperature of the protected object and to feed it to the device via an RTD unit. The function Thermal overload protection receives the measured temperature value via the function RTD unit Ether. or RTD unit Serial from the function group Analog units.

Parameter: Default temperature

- Recommended setting value (_:110) Default temperature = 40°C

Under the following conditions, the Default temperature will be set as ambient temperature:

- A temperature sensor for measuring the ambient temperature is not connected
- The temperature measurement is interrupted and the measured temperature value is less than the Default temperature.

Siemens recommends using the default setting.

Parameter: Minimal temperature

- Default setting (_:117) Minimal temperature = -20°C

If the measured ambient temperature drops below the preset value, the set value will be assumed as the ambient temperature. If the overload protection works with a prespecified outside temperature, and the temperature drops below the value set in the Minimal temperature parameter, the Minimal temperature can also be used.

6.21.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
49 Th.overl. #				
_:1	49 Th.overl. #:Mode		• off • on • test	off
_:2	49 Th.overl. #:Operate & flt.rec. blocked		• no • yes	no
_:101	49 Th.overl. #:Threshold current warning	1 A @ 100 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	1.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	5.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	1.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	5.000 A
_:104	49 Th.overl. #:Threshold thermal warn.		50 % to 100 %	90 %
_:105	49 Th.overl. #:Dropout threshold operate		50 % to 99 %	90 %
_:106	49 Th.overl. #:K-factor		0.10 to 4.00	1.10
_:110	49 Th.overl. #:Thermal time constant		10 s to 60000 s	900 s
_:107	49 Th.overl. #:Imax thermal	1 A @ 100 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 100 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	2.500 A
		5 A @ 50 Irated	0.15 A to 50.00 A	12.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.500 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	12.500 A
_:109	49 Th.overl. #:Temperature rise at Irated		40 K to 200 K	70 K
_:113	49 Th.overl. #:Storage of thermal replica		• no • yes	no
_:114	49 Th.overl. #:Behav. at I> Imax therm.		• current limiting • freeze therm. rep.	current limiting
_:118	49 Th.overl. #:Default temperature		-55°C to 55°C	40°C

Addr.	Parameter	C	Setting Options	Default Setting
_:117	49 Th.overl. #:Minimal temperature		-55°C to 40°C	-20°C
_:44	49 Th.overl. #:Tempera. sensor		Setting options depend on configuration	

6.21.6 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

6.22 Unbalanced-Load Protection

6.22.1 Overview of Functions

The Unbalanced-load protection function detects unbalanced loads or line interruptions 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.

6.22.2 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 6-167 Structure/Embedding of the Function

6.22.3 Function Description

Logic of the Stage

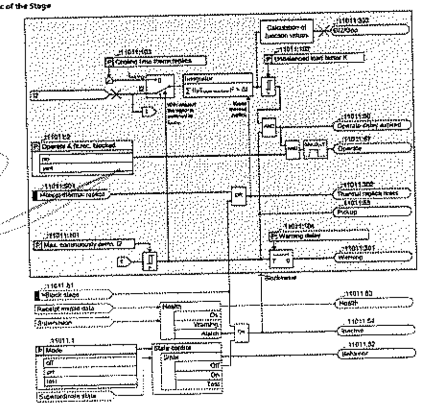


Figure 6-168 Logic Diagram of the Unbalanced-Load Protection Function

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:

$$t_{Perm} = \frac{K}{(I_2/I_{rated\,machine})^2}$$

With:

t_{Perm}	Permissible time of the negative-sequence current
K	Unbalanced-load factor of the machine (parameter Unbalanced load factor K)
$I_2/I_{rated\,machine}$	Actual unbalanced-load current as a per unit value (negative-sequence current/rated current of the machine)

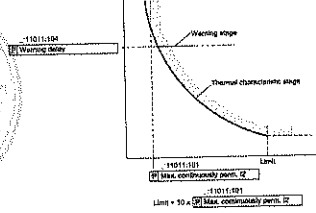


Figure 6-169 Operate Curve of the Unbalanced-Load Protection

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. The factor is typically 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 ΘI2/Θop:

$$\Theta I2/\Theta op = \frac{\sum_{0}^{t}(I_2/I_{rated\,machine})^2 \cdot \Delta t}{K} \cdot 100\,\%$$

With

ΘI2/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)
$I_2/I_{rated\,machine}$	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.

6.22.4 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 points:

- Design of the machine (salient pole or non-salient 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

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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 having 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.

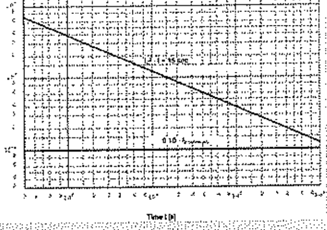

Figure 6-170 Example of an Unbalanced-Load Characteristic Specified by the Machine Manufacturer

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 6-170. You can read the time corresponding to Unbalanced load factor K at the point $I_2 / I_{rated,obj} = 1$. In the example, this is the p.u. value "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. I2 = 10.0 % (corresponds to 0.1)
Unbalanced load factor K = 15 s
Cooling time therm. replica = 1500 s

6.22.5 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

6.22.6 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
_:11011:501	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:θI2/θop	MV	O

6.23 Overvoltage Protection with 3-Phase Voltage

6.23.1 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

6.23.2 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.

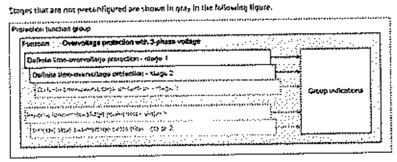

Figure 6-171 Structure/Embedding of the Function

6.23.3 Stage with Definite-Time Characteristic Curve

6.23.3.1 Description

Logic of the Stage

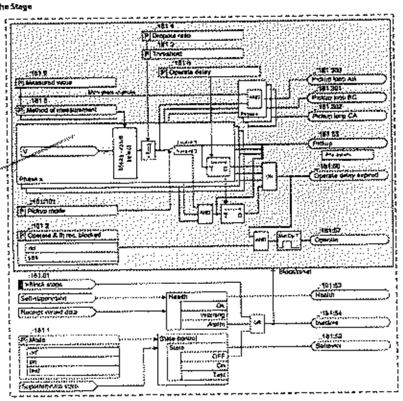

Figure 6-177 Logic Diagram of the Definite Time-Overvoltage Protection with 3-Phase Voltage

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.

6.23.3.2 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 unbalances and overvoltage conditions caused by ground faults.

Parameter: Threshold

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

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

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

Parameter: Operate delay

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

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

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

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

Parameter: Pickup mode

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

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

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

Operation as Supervision Function

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

EXAMPLE

Example for 2-stage overvoltage protection

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

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

Threshold value: 10 % above V_{rated}

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

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

For the Operate delay set a value of 3 s.

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

Stage	Setting Values	
	Threshold value	Time delay
1	Time delay 1.1 V_{rated}	3 s

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Stage	Setting Values	
2	1.5 V_{thre}	0.1 s to 0.2 s

6.23.3.3 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

6.23.3.4 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
_: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

6.23.4 Stage with Inverse-Time Characteristic Curve

6.23.4.1 Description

Logic of the Stage

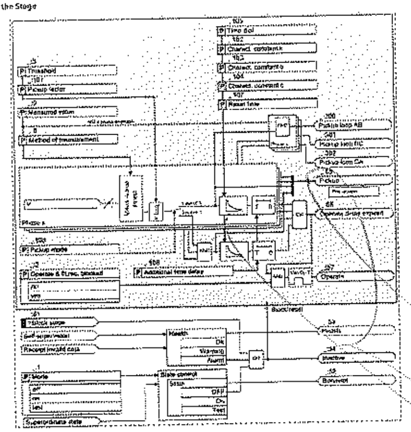

Figure 6-173 Logic Diagram of the Inverse Time-Overvoltage Protection with 3-Phase Voltage

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.

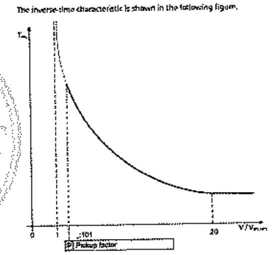

Figure 6-174 Operate Curve of Inverse-Time Characteristic

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

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

Where

T_{inv} Inverse-time delay

T_p Time multiplier (parameter Time dial)

V Measured voltage

V_{thresh} Threshold value (parameter Threshold)

k Curve constant k (parameter Charact. constant k)

α Curve constant α (parameter Charact. constant α)

c Curve constant c (parameter Charact. constant c)

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

Dropout Behavior

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

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

ВЯРНО С ОРИГИНАЛА

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.

6.23.4.2 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 (_:101) Pickup factor = 1.10

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

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

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

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

Parameter: Pickup mode

- Recommended setting value (_:182:101) Pickup mode = 1 out of 3

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

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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 (_:102) Charact. constant k = 1.00
- Default setting (_:103) 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.

6.23.4.3 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.
_:108	Inverse-T #:Pickup mode		• 1 out of 3 • 3 out of 3	1 out of 3
_:3	Inverse-T #:Threshold		0.300 V to 340.000 V	110.000 V
_:101	Inverse-T #:Pickup factor		1.00 to 1.20	1.10
_:102	Inverse-T #:Charact. constant k		0.00 to 300.00	1.00
_:103	Inverse-T #:Charact. constant α		0.010 to 5.000	1.000
_:104	Inverse-T #:Charact. constant c		0.000 to 5.000	0.000
_:105	Inverse-T #:Time dial		0.05 to 15.00	1.00
_:106	Inverse-T #:Additional time delay		0.00 s to 60.00 s	0.00 s
_:107	Inverse-T #:Reset time		0.00 s to 60.00 s	0.00 s

6.23.4.4 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

6.24 Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage

6.24.1 Overview of Functions

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

- 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.

6.24.2 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.

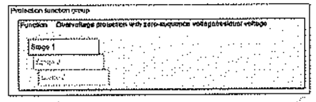

Figure 6-175 Structure/Embedding of the Function

6.24.3 Stage Description

Logic of a Stage

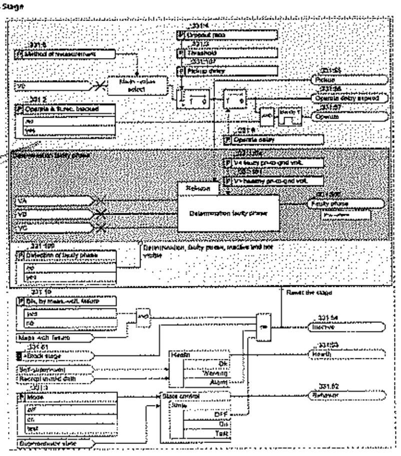

Figure 6-176 Logic Diagram of an Overvoltage Protection with Zero-Sequence Voltage/Residual Voltage Stage

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 pickup of the measuring-voltage failure detection function (see chapter 9.3.2.1 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.

6.24.4 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.
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 (= 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 winding.

- 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 on 50 % of the full residual voltage.
- At full residual voltage, the zero-sequence voltage is 100 V/√3 = 57.7 V
  Setting value: 0.5 * 57.7 V = 28.9 V ≈ 30 V

Parameter: Dropout ratio

- Recommended setting value (_: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] The specific setting limits depend on the transformer data and [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 VTCB is connected to the voltage-transformer circuit breaker (see Chapter 9.5.4.7 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 (_:331:109) Detection of faulty phase = no

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

Parameter Value	Description
no	The phase affected by the ground fault is not determined. Select the default setting if you do not want to use the stage to detect ground faults, for example, 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 (_:331:104) V< faulty ph-to-gnd volt. = 30.000 V[14]

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 (_:331:101) V> healthy ph-to-gnd volt. = 75.000 V[15]

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.

[14] The specific setting limits depend on the transformer data and transformer connections set.
[15] The specific setting limits depend on the transformer data and transformer connections set.

6.24.5 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
_:331:109	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 200.000 V	75.000 V
_:331:104	Stage 1:V< faulty ph-to-gnd volt.		0.300 V to 200.000 V	30.000 V

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
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
_:331:300	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

6.25 Overvoltage Protection with Positive-Sequence Voltage

6.25.1 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.

6.25.2 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.

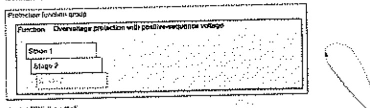

Figure 6-177 Structure/Embedding of the Function

6.25.3 Stage Description

Logic of a Stage

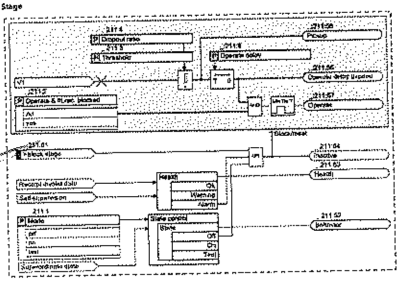

Figure 6-178 Logic Diagram of a Stage: Overvoltage Protection with Positive-Sequence Voltage

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.

6.25.4 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.

6.25.5 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

6.25.6 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

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6.26 Overvoltage Protection with Negative-Sequence Voltage

6.26.1 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.

6.26.2 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.

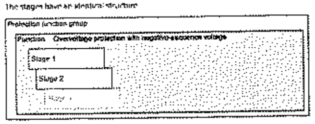

Figure 6-179 Structure/Embedding of the Function

6.26.3 General Functionality

6.26.3.1 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.

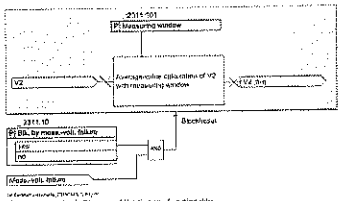

Figure 6-180 Logic Diagram of the General Functionality

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 the 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 pick up of the Measuring-voltage failure detection function (see section 9.3.2.1 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.

6.26.3.2 Application and Setting Notes

Parameter: Measuring window

- Default setting (_:2311:101) `Measuring window = 2 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 12.32 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 9.3.4.1 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.

6.26.3.3 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

6.26.3.4 Information List

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

6.26.4 Stage with Negative-Sequence Voltage

6.26.4.1 Description

Logic of a Stage

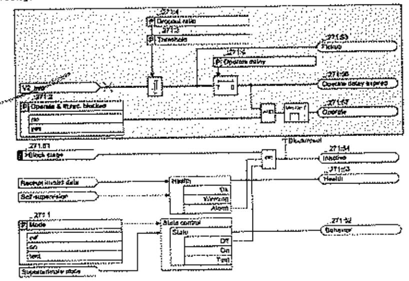

Figure 6-181 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage

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 6.26.3.1 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*

6.26.4.2 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 6-182 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.

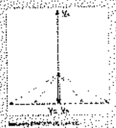

Figure 6-182 Voltage Phasors during a 2-Phase Local Fault

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:

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

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 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.

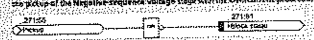

Figure 6-183 Linking the Pickup of the Negative-Sequence Voltage Stage

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 in 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 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 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 6-14. 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 6-14 Recommended Settings

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

6.26.4.3 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

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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	5,000 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

6.26.4.4 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	ACT	O

6.27 Overvoltage Protection with Any Voltage

6.27.1 Overview of Functions

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

6.27.2 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.

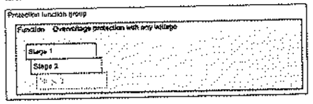

Figure 6-184 Structure/Embedding of the Function

6.27.3 Stage Description

Logic of a Stage

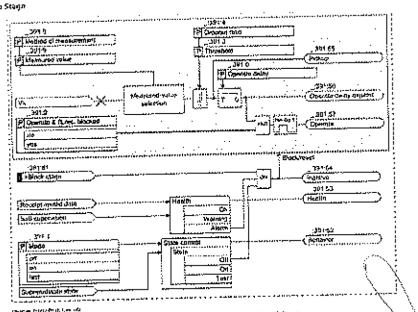

Figure 6-185 Logic Diagram of a Stage: Overvoltage Protection with Any Voltage

> **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`.

6.27.4 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.

6.27.5 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

6.27.6 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

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

6.28.1 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 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.

6.28.2 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.

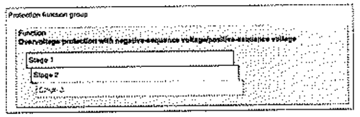

Figure 6-186 Structure/Embedding of the Function

6.28.3 General Functionality

6.28.3.1 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.

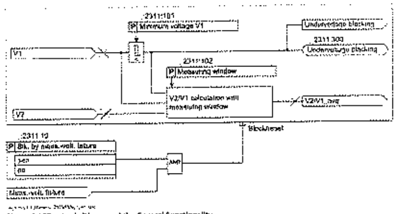

Figure 6-187 Logic Diagram of the General Functionality

Measurand

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 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 pick up of the **Measuring-voltage failure detection** function (see section 9.3.2.1 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.

6.28.3.2 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 12.35 *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 9.3.2.1 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.

6.28.3.3 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

6.28.3.4 Information List

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

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

6.28.4.1 Description

Logic of a Stage

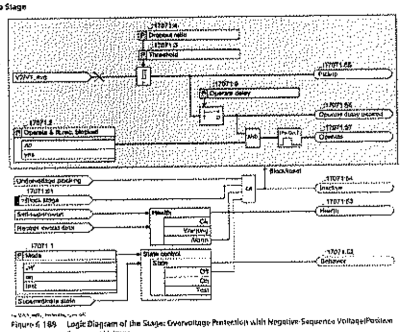

Figure 6-188 Logic Diagram of the Stage: Overvoltage Protection with Negative-Sequence Voltage/Positive-Sequence Voltage

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 6.28.3.1 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*

6.28.4.2 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 6-189 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.

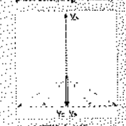

Figure 6-189 Voltage Phasors during a 2-Phase Local Fault

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.

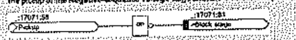

Figure 6-190 Linking the Pickup of the Negative-Sequence Voltage Stage

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 at 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 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 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 6-15.

Table 6-15 Recommended Settings

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

6.28.4.3 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

6.28.4.4 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

6.29 Undervoltage Protection with 3-Phase Voltage

6.29.1 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

6.29.2 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 6-191). 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.

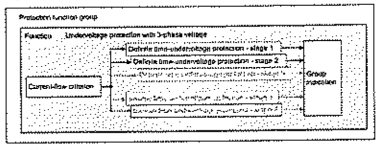

Figure 6-191 Structure/Embedding of the Function

6.29.3 Stage with Definite-Time Characteristic Curve

6.29.3.1 Description

Logic of a Stage

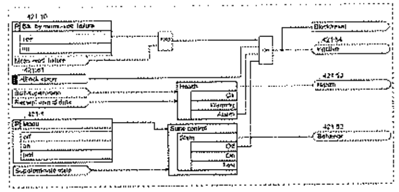

Figure 6-192 Logic Diagram of the Stage Control

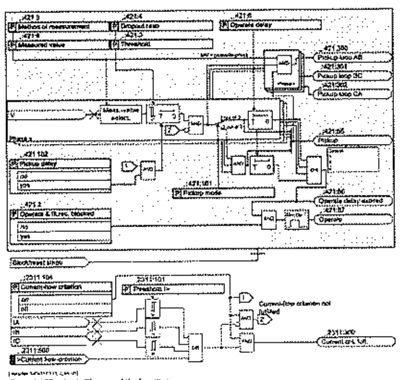

Figure 6-193 Logic Diagram of the Function

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

Measured Value

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

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

Pickup Mode

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

Pickup Delay

The Pickup delay parameter is only 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 6-193 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 pick up of the measuring-voltage failure detection function (see section 9.3.2.1 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.

6.29.3.2 Application and Setting Notes

Parameter: Method of measurement

- Recommended setting value (_:421:8) Method of measurement = fundamental comp.

Use the Method of measurement parameter to 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 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 stage under 10 V for this method of measurement.

Parameter: Measured value

- Recommended setting value (_:421:9) Measured value = phase-to-phase

Use the Measured value parameter to 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

Parameter Value	Description
phase-to-phase	If you want to detect voltage dips caused by multiphase short circuits, or generally monitor the voltage range, keep phase-to-phase as the default setting. 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 or overvoltage conditions caused by ground faults.

Parameter: Threshold

- Default setting (_:421:3) Threshold = 80 V

The Threshold is set in accordance with the Measured value as either a phase-to-phase or phase-to-ground variable.

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

For the default setting, the lower limit of the voltage range to be monitored is assumed to be 80% of the rated voltage of the protected object.

EXAMPLE:

Rated voltage of the protected object: $V_{rated,obj} = 10\,kV$

Voltage transformer: $Ratio_V = \frac{10\,kV/\sqrt{3}}{100\,V/\sqrt{3}}$

Threshold value: 80% of $V_{rated,obj}$

The secondary setting value is calculated as follows:

$$V_{Threshold\,value,sec} = \frac{0.8 \cdot V_{rated,obj}}{Ratio_V} = \frac{0.8 \cdot 10\,kV \cdot 100\,V}{10\,kV} = 80\,V$$

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).

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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.

Parameter: Operate delay

- Default (_:421:6) Operate delay = 3 s

The Operate delay must be set for the specific application.

Parameter: Dropout ratio

- Recommended setting value (_:421:4) Dropout ratio = 1.05

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

Parameter: Blk. by meas.-volt. failure

- Default setting (_:421:10) Blk. by meas.-volt. failure = yes

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

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

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on.
- The binary input signal >Open of the function block VTCB is connected to the voltage transformer circuit breaker (see Chapter 9.3.4.1 Overview of Functions).

Parameter Value	Description
yes	The protection stage is blocked (= default setting). Siemens recommends using the default setting.

Parameter Value	Description
no	The protection stage is not blocked.

Parameter: Current-flow criterion

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

Depending on the system, the voltage transformers are arranged either on the supply side or the junction 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 junction side, the voltage is cleared

Parameter Value	Description
on	If the voltage transformers are located on the junction side, you can use the current-flow criterion to make the pickup fall back when the current falls below a minimum value (parameter Threshold I>).
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 Threshold I> parameter makes it possible to detect when the circuit-breaker is closed. Siemens recommends setting 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, compensation processes in the secondary circuit of the current transformer will 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 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.

6.29.3.3 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

Addr.	Parameter	C	Setting Options	Default Setting
_: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.
_: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

6.29.3.4 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

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

6.29.4 Stage with Inverse-Time Characteristic Curve

6.29.4.1 Description

Logic

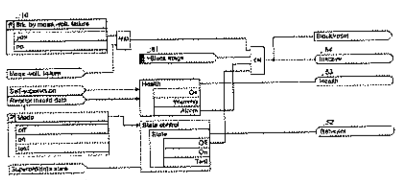

Figure 6-194 Logic Diagram of the Stage Control

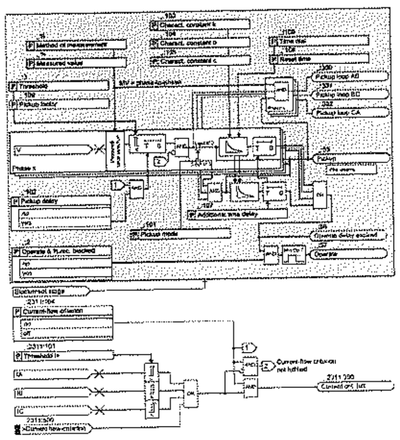

Figure 6-195 Logic Diagram of the Function

Method of Measurement

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

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

Measured Value

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

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

Pickup Mode

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

Pickup and Operate Curve

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

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

Where:

T_{op} Operate delay

T_{inv} Inverse-time delay

T_{add} Additional time delay (Parameter Additional time delay)

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

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

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

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:

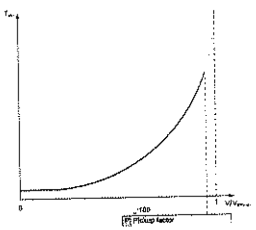

Figure 6-196 Inverse-Time Characteristics for Undervoltage Protection

Pickup Delay

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

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

Dropout Behavior

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

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

Current-Flow Criterion

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

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

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

Figure 6-197 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 9.3.2.1 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.

6.29.4.2 Application and Setting Notes

Parameter: Method of measurement

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

Use the Method of measurement parameter to 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 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 stage under 10 V for this method of measurement.

Parameter: Measured value

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

Use the Measured value parameter to 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 detect voltage dips caused by multiphase short circuits, or generally monitor the voltage range, keep phase-to-phase as the default setting. 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 or overvoltage conditions caused by ground faults.

Parameter: Threshold, Pickup factor

- Default setting (_:3) Threshold = 80.000 V
- Default setting (_:109) Pickup factor = 0.90

The stage picks up when the measured voltage value falls below 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, you modify the pickup value. To avoid a long operate delay time after pickup, Siemens recommends using the default value of Pickup factor.

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

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

Parameter: Pickup delay

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

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

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

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

Parameter: Blk. by meas. volt. failure

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

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

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

- The device-internal supervision function Measuring-voltage failure detection is configured and switched on.
- The binary input signal >Open of the function block VTCB is connected to the voltage-transformer circuit breaker (see chapter 9.3.4.1 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 are arranged either on the supply side or the junction 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 junction side, the voltage is cleared.

Parameter Value	Description
on	If the voltage transformers are located on the junction side, you can use the current-flow criterion to make the pickup fall back when the current falls below a minimum value (parameter Threshold I>).
off	Since the voltage is switched off, the pickup of the undervoltage protection stage persists when the current-flow criterion is not used.

6.29.4.3 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
_: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
_: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

6.29.4.4 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

6.30 Undervoltage Protection with Positive-Sequence Voltage

6.30.1 Overview of Functions

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

- 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 three 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.

6.30.2 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 6-197). 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.

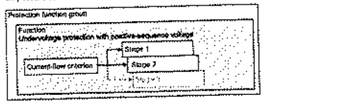

Figure 6-197 Structure/Embedding of the Function

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6.30.3 Stage Description

Logic of a Stage

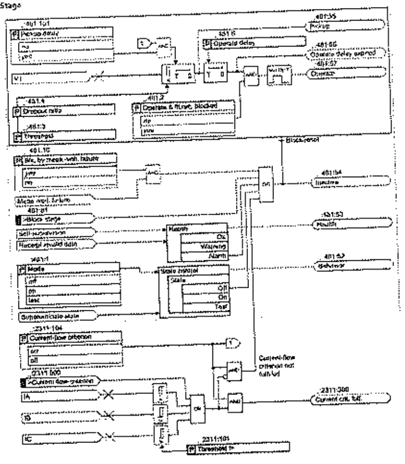

Figure 6-198 Logic Diagram of a Stage: Undervoltage Protection with Positive-Sequence Voltage

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 must not 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 6-198 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. This 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 9.3.1 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.

6.30.4 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 lower voltage range, 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 VTCB is connected to the voltage transformer circuit breaker (see chapter 9.3.1 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 value I>).

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 Threshold I> parameter 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, compensation 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.

EXAMPLE of a 2-stage undervoltage protection

The undervoltage protection can be used for the protection of motors within the power plant's own power system. The example describes the possible settings for a two-stage undervoltage-protection function. We will look at the settings of the parameters Threshold and Operate delay.

1. Stage:

Set the Threshold to approx. 80 % of the rated voltage. In the case of voltage dips down to that value, the motors can still start up. Depending on the loading characteristic, the Threshold can also be set somewhat lower.

The following data apply:

Rated motor voltage: $V_{rated,M} = 6\ kV$

Minimum startup voltage: 80 % of rated motor voltage

Voltage transformer ratio:

$$Ratio_V = \frac{6\ kV/\sqrt{3}}{100\ V/\sqrt{3}}$$

When setting the threshold value, make sure that the positive-sequence voltage as defined is equal to the value of one phase-to-ground voltage. Taking into account the rated primary voltage of the motor, the primary setting value of the first stage is calculated as follows:

$$V_{prim} = 0.8 \cdot V_{rated,L} = 0.8 \cdot \frac{6\ kV}{\sqrt{3}} = 2.77\ kV$$

When setting secondary values, you calculate the secondary setting value as follows, taking into account the voltage-transformer ratio:

$$V_{sec} = \frac{V_{prim}}{Ratio_V} = \frac{2.77\ kV}{6\ kV/\sqrt{3}} \cdot 100\ V/\sqrt{3} = 46.2\ V$$

Set a value of 3 s for the Operate delay.

2. Stage:

Undervoltage cause excessive torques and current surges which place inadmissible strains on the motor. The voltage at which motors do no longer start up is in the range of (0.55 ... 0.70) V_{rated}. If no data are available, use the empirical value of approx. 70% of the rated voltage for setting the parameter Threshold. Set the Operate delay so that it slightly overlaps the tripping time of the overcurrent protection for the power-plant auxiliary power. Unless otherwise required by the motor manufacturer, set a Operate delay between 0.5 s and 3 s. The shorter time should be preferred.

Stage	Setting Values	
	Threshold value	Time delay
1	0.70 to 0.85 V_{rated} (for example, 0.80 V_{rated})[1]	Approx. 5 to 5 s
2	0.55 to 0.70 V_{rated} (for example, 0.70 V_{rated})[1]	0.5 s to 3 s

6.30.5 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
_:482:101	Stage 2:Pickup delay		• no • yes	no
_:482:3	Stage 2:Threshold		0.300 V to 200.000 V	40.000 V

Addr.	Parameter	C	Setting Options	Default Setting
_: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	0.50 s

6.30.6 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

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6.31 Undervoltage Protection with Any Voltage

6.31.1 Overview of Functions

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

6.31.2 Structure of the Function

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

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

The protection function is structured such that one current-flow criterion can act on all undervoltage protection stages (see Figure 6-199).

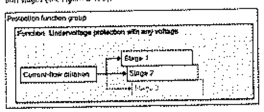

Figure 6-199 Structure/Embedding of the Function

6.31.3 Stage Description

Logic of a Stage

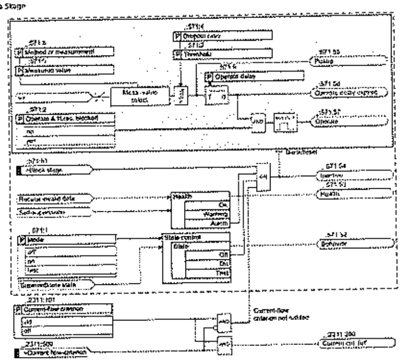

Figure 6-200 Logic Diagram of a Stage: Undervoltage Protection with Any Voltage

> **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 6-200 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.

6.31.4 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 = 80 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.

6.31.5 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

6.31.6 Information List

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

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6.32 Overfrequency Protection

6.32.1 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.

6.32.2 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.

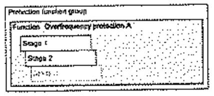

Figure 6-201 Structure/Embedding of the Function

6.32.3 Overfrequency-Protection Stage

Logic of a Stage

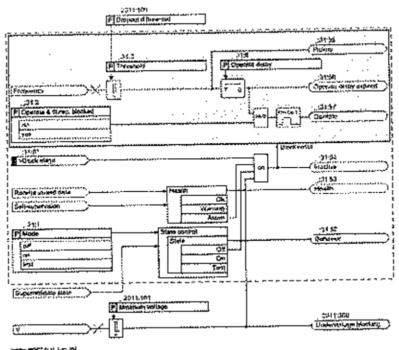

Figure 6-202 Logic Diagram of the Overfrequency Protection Stage

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

6.32.4 Application and Setting Notes

Frequency-Measurement Method

The frequency measurement method is selected with the functional configuration from the DIGSI functions library. The letter at the end of the function name describes the method of measurement.

Redundant solutions can be implemented by combining 2 different methods of frequency measurement. You can implement a 2-out-of-2 decision by connecting the operate indications of both functions in a CFC with a logical AND gate. This increases the reliability of protection.

Frequency-Measurement Method	Description
Angle difference method (method A)	Select this method of measurement if the frequency protection stage is used for the protection of machines.
Filtering method (method B)	Select this method of measurement if the frequency protection stage is used in an electrical power system.

Parameter: Threshold

- Recommended setting value (_:31:3) Threshold = 50.20 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. 50.20 Hz is a typical warning threshold in 50-Hz systems.

Parameter: Operate delay

- Recommended setting value (_:31:6) Operate delay = 10 s

The Operate delay parameter is used to set the stage so that overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value (_:2311:101) Minimum voltage = 37.5 V

For the Undervoltage blocking, 65 % of the protected object's rated voltage is recommended.

When determining the setting value, please keep in mind the measurement method and the measuring connection that you have selected. If you work with the positive-sequence voltage, remember that the maximum voltage is equal to the phase-to-ground voltage. The default setting is referred to this value.

Parameter: Dropout differential

- Recommended setting value (_:2311:109) Dropout differential = 20 mHz

Due to the high-precision frequency measurement, the recommended setting value for the Dropout differential can remain at 20 mHz. 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 50.20 Hz and the Dropout differential to 100 mHz, the stage will drop out at 50.10 Hz.

Application example of the overfrequency protection:

Overfrequency protection can be used for monitoring the frequency range. If the frequency deviates from the rated frequency by for example, 0.2 Hz, a fault indication is generated. The trip command is delayed to avoid overfunction due to disturbing influences (for example, switching operations). A delay of a few seconds (for example, 10 s) is deemed to be a good value. You can leave the Dropout differential at the default value of 20 mHz. The following table shows a setting recommendation.

For this application, 1 stage of the overfrequency protection is 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	50.20 Hz	60.20 Hz	10.00
f2>	Not used (OFF)			

NOTE

This table shows one example of a possible frequency protection setting. The setting values can differ depending on the application.

6.32.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Minimum voltage		3.000 V to 175.000 V	37.500 V
_:2311:109	General:Dropout differential		20 mHz to 2000 mHz	20 mHz
Stage 1				
_:31:1	Stage 1:Mode		• off • on • test	off
_:31:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:31:3	Stage 1:Threshold		40.00 Hz to 70.00 Hz	51.50 Hz
_:31:6	Stage 1:Operate delay		0.00 s to 600.00 s	10.00 s
Stage 2				
_:32:1	Stage 2:Mode		• off • on • test	off
_:32:2	Stage 2:Operate & flt.rec. blocked		• no • yes	no
_:32:3	Stage 2:Threshold		40.00 Hz to 70.00 Hz	54.00 Hz

Addr.	Parameter	C	Setting Options	Default Setting
_:32:6	Stage 2:Operate delay		0.00 s to 600.00 s	5.00 s

6.32.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:f	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:31:81	Stage 1:>Block stage	SPS	I
_:31:54	Stage 1:Inactive	SPS	O
_:31:52	Stage 1:Behavior	ENS	O
_:31:53	Stage 1:Health	ENS	O
_:31:55	Stage 1:Pickup	ACD	O
_:31:56	Stage 1:Operate delay expired	ACT	O
_:31:57	Stage 1:Operate	ACT	O
Stage 2			
_:32:81	Stage 2:>Block stage	SPS	I
_:32:54	Stage 2:Inactive	SPS	O
_:32:52	Stage 2:Behavior	ENS	O
_:32:53	Stage 2:Health	ENS	O
_:32:55	Stage 2:Pickup	ACD	O
_:32:56	Stage 2:Operate delay expired	ACT	O
_:32:57	Stage 2:Operate	ACT	O

6.33 Underfrequency Protection

6.33.1 Overview of Functions

The Underfrequency protection function (ANSI 81U) is used to:

- Detect underfrequencies in electrical power systems or machines
- Monitor the frequency band and output failure indications
- Decouple power systems
- Load shedding to ensure power system stability and protect motors
- Disconnect generating units when the power system frequency is critical (for example, f < 0.95 f_{rated})

Frequency deviations are caused by an unbalance between the active power generated and consumed. 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.

6.33.2 Structure of the Function

The Underfrequency protection function is used in protection function groups, which are based on voltage measurement.

The Underfrequency protection function comes with 3 factory-set stages. A maximum of 5 tripping stages can be operated simultaneously in the function. The tripping stages have an identical structure.

The parameters Dropout differential and Minimum voltage are set for all stages.

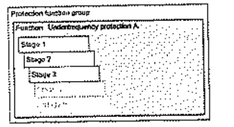

Figure 6-203 Structure/Embedding of the Function

6.33.3 Underfrequency-Protection Stage

Logic of a Stage

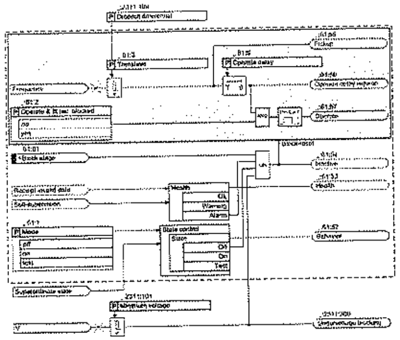

Figure 6-204 Logic Diagram of the Underfrequency Protection Stage

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 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:

- Via the binary input signal >Block stage from an external or internal source
- Internally when the voltage drops below the Minimum voltage

6.33.4 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 overfunctions due to disturbing influences (for example, switching operations) are avoided. Fairly high time delays are sufficient for warning indications.

Parameter: Minimum voltage

- Recommended setting value (_:2311:101) Minimum voltage = 37 500 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 want 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.

Application example of the underfrequency protection

Frequency protection can be used for load shedding. The UCTE has defined a 5-stage plan for the Western European power grid. The setting values of the stages are based on that plan (see table below).

Table 6-16 Stage Plan

Frequency	Activity
49.80 Hz	Alarm and activation of reserves following an established plan
49.00 Hz	Undelayed disconnection of 10 % to 15 % of the power system load
48.70 Hz	Undelayed disconnection of another 10 % to 15 % of the power system load
48.40 Hz	3rd load shedding stage. Another 15 % to 20 % of the power system load is disconnected.
47.50 Hz	Power plants are decoupled from the electrical power system

For this application, 3 stages of the underfrequency protection are used. 2 of these stages are used for load shedding. 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<	1st load shedding	49.00 Hz	59.00 Hz	0.00
f3<	2nd load shedding	48.70 Hz	58.70 Hz	0.00

> **NOTE**
> This table shows an example of a possible frequency protection setting. The setting values can differ depending on the application.

6.33.5 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	49.80 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

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	10.00 s

6.33.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Stage 1			
_:61:81	Stage 1:>Block stage	SPS	I
_:61:54	Stage 1:Inactive	SPS	O
_:61:52	Stage 1:Behavior	ENS	O
_:61:53	Stage 1:Health	ENS	O
_:61:55	Stage 1:Pickup	ACD	O
_:61:56	Stage 1:Operate delay expired	ACT	O
_:61:57	Stage 1:Operate	ACT	O
Stage 2			
_:62:81	Stage 2:>Block stage	SPS	I
_:62:54	Stage 2:Inactive	SPS	O
_:62:52	Stage 2:Behavior	ENS	O
_:62:53	Stage 2:Health	ENS	O
_:62:55	Stage 2:Pickup	ACD	O
_:62:56	Stage 2:Operate delay expired	ACT	O
_:62:57	Stage 2:Operate	ACT	O
Stage 3			
_:63:81	Stage 3:>Block stage	SPS	I
_:63:54	Stage 3:Inactive	SPS	O
_:63:52	Stage 3:Behavior	ENS	O
_:63:53	Stage 3:Health	ENS	O
_:63:55	Stage 3:Pickup	ACD	O
_:63:56	Stage 3:Operate delay expired	ACT	O
_:63:57	Stage 3:Operate	ACT	O

6.34 Rate of Frequency Change Protection

6.34.1 Overview of Functions

The function Rate of frequency change protection is used to:

- Detect a frequency change quickly
- Prevent the system from not secure states caused by unbalance between the generated and consumed active power
- Network decoupling
- Load shedding

6.34.2 Structure of the Function

The function Rate of frequency change protection can be used in protection function groups containing a 3-phase voltage measurement.

2 function block types are available:

- df/dt rising
- df/dt falling

The function Rate of frequency change protection is preconfigured by the manufacturer with 1 df/dt rising stage and 1 df/dt falling stage. A maximum of 5 df/dt rising stages and 5 df/dt falling stages can operate simultaneously within the function. Both of the function block types are similar in structure.

Undervoltage check and df/dt calculation are general functionalities and take place on the function level. All stages use these general functionalities.

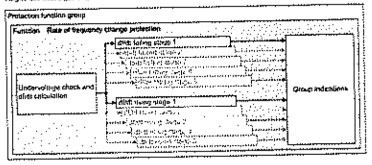

Figure 6-205 Structure/Embedding of the Function

6.34.3 General Functions (Undervoltage Test, df/dt Calculation)

6.34.3.1 Description

Logic

The following figure represents the logic of undervoltage check and df/dt calculation. It applies to all types of stages.

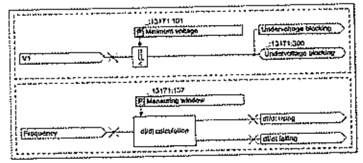

Figure 6-206 Logic Diagram of General Functionality

Measurand

This function uses the frequency calculated via the angle difference algorithm.

For more information, refer to chapter 6.32.3 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 4 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

6.34.3.2 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 sound 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.

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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.

6.34.4 Stage Description

6.34.4.1 Description

Logic of the Stage

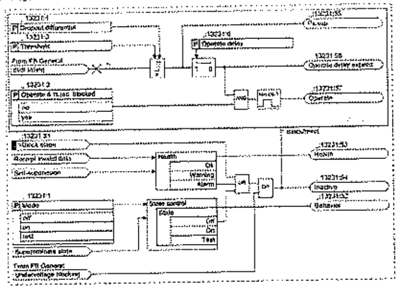

Figure 6-207 Logic Diagram of Rate of Frequency Change Protection

(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

6.34.4.2 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 magnitude 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.

6.34.5 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

6.34.6 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

No.	Information	Data Class (Type)	Type
_:13231:53	df/dt falling1:Health	ENS	O
_:13231:55	df/dt falling1:Pickup	ACD	O
_:13231:56	df/dt falling1:Operate delay expired	ACT	O
_:13231:57	df/dt falling1:Operate	ACT	O
df/dt rising1			
_:13201:81	df/dt rising1:>Block stage	SPS	I
_:13201:54	df/dt rising1:Inactive	SPS	O
_:13201:52	df/dt rising1:Behavior	ENS	O
_:13201:53	df/dt rising1:Health	ENS	O
_:13201:55	df/dt rising1:Pickup	ACD	O
_:13201:56	df/dt rising1:Operate delay expired	ACT	O
_:13201:57	df/dt rising1:Operate	ACT	O

6.35 Power Protection (P,Q), 3-Phase

6.35.1 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)

6.35.2 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.

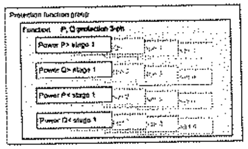

Figure 6-208 Structure/Embedding of the Function

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.

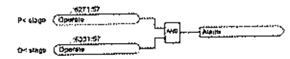

Figure 6-209 Logical Combination of Operate Indications in CFC

6.35.3 Active Power Stage

Logic of a Stage

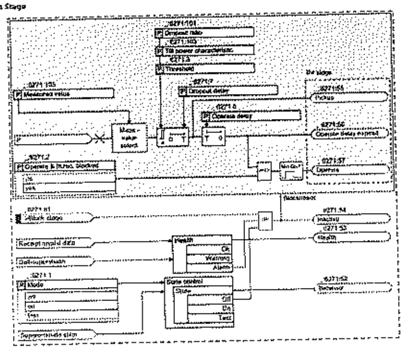

Figure 6-210 Logic Diagram of the Active Power Stage (Stage Type: Power P<)

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 powers power of phase A, power of phase B or power of phase C.

Pickup Characteristic

With the stage type you specify if the stage work as a greater stage (stage type: Power P>) or as a smaller stage (stage type: Power P<).

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.

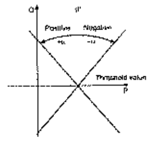

Figure 6-211 Tilt Power Characteristic

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.

6.35.4 Reactive Power Stage

Logic of a Stage

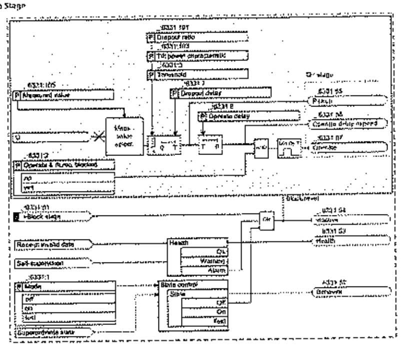

Figure 6-212 Logic Diagram of the Reactive Power Stage (Stage Type: Power Q<)

Measured Value

The Measured value parameter is used to specify which measured power value is processed by the tripping stage. Possible settings are positive seq. power and the phase-selective powers power of phase A, power of phase B or power of phase C.

Pickup Characteristic

With the stage type you specify if the stage 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.

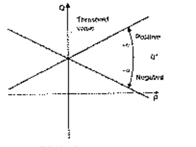

Figure 6-213 Tilt Power Characteristic

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.

6.35.5 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 6-214 tripping zone defined by characteristics), an alarm indication is generated. For this purpose, you have to make an AND operation of the stage indications of the active and reactive power stage in CFC. The function used is 3-phase power measurement. Figure 6-214 shows the threshold values and the location of the characteristics in the PQ diagram.

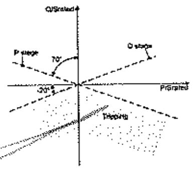

Figure 6-214 Pickup Values and Characteristic Curves

6.35.6 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 6-211).

Parameter: Dropout delay

- Recommended setting value (_:6271:7) Dropout delay = 20 ms

The Dropout delay parameter maintains the pickup even if the measured value drops momentarily below the threshold value. A delay is required for very low pickup values to prevent a so-called chattering of the function. In the example, the setting value is 20 ms.

Parameter: Operate delay

- Recommended setting value (_:6271:6) Operate delay = 100 ms

The Operate delay must be set for the specific application. In the example, a setting value of 100 ms has been selected.

6.35.7 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 6-214), the power characteristic has a tilt of 20°. Set the Tilt power characteristic parameter to +20° (for a definition of the sign, see Figure 6-213).

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.

6.35.8 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Power P> 1				
_:6241:1	Power P> 1:Mode		• off • on • test	off
_:6241:2	Power P> 1:Operate & flt.rec. blocked		• no • yes	no
_:6241:104	Power P> 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6241:3	Power P> 1:Threshold		-200.0 % to 200.0 %	80.0 %
_:6241:101	Power P> 1:Dropout ratio		0.90 to 0.99	0.95
_:6241:103	Power P> 1:Tilt power characteristic		-89.0° to 89.0°	0.0°
_:6241:7	Power P> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6241:6	Power P> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power P< 1				
_:6271:1	Power P< 1:Mode		• off • on • test	off
_:6271:2	Power P< 1:Operate & flt.rec. blocked		• no • yes	no
_:6271:105	Power P< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6271:3	Power P< 1:Threshold		-200.0 % to 200.0 %	5.0 %
_:6271:101	Power P< 1:Dropout ratio		1.01 to 1.10	1.05
_:6271:103	Power P< 1:Tilt power characteristic		-89.0° to 89.0°	0.0°

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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 %	70.0 %
_:6301:101	Power Q> 1:Dropout ratio		0.90 to 0.99	0.95
_:6301:103	Power Q> 1:Tilt power characteristic		-89.0 ° to 89.0 °	0.0 °
_:6301:7	Power Q> 1:Dropout delay		0.00 s to 60.00 s	0.00 s
_:6301:6	Power Q> 1:Operate delay		0.00 s to 60.00 s	1.00 s
Power Q< 1				
_:6331:1	Power Q< 1:Mode		• off • on • test	off
_:6331:2	Power Q< 1:Operate & flt.rec. blocked		• no • yes	no
_:6331:105	Power Q< 1:Measured value		• power of phase A • power of phase B • power of phase C • positive seq. power	positive seq. power
_:6331:3	Power Q< 1:Threshold		-200.0 % to 200.0 %	-50.0 %
_: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

6.35.9 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

6.36 Reverse Power Protection

6.36.1 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 or tactive) 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.

6.36.2 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.

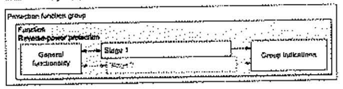

Figure 6-215 Structure/Embedding of the Function

6.36.3 General Functionality

6.36.3.1 Description

Logic of the Function

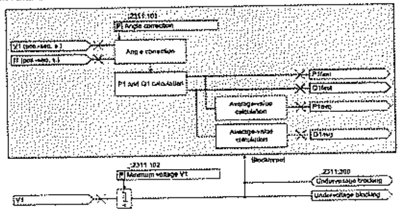

Figure 6-216 Logic Diagram of the Cross-Stage Functionality

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 11-2).

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-component 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:

$$\underline{S} = 3\underline{V}_1 \cdot \underline{I}_1^* = 3V_1 e^{j\varphi_V} \cdot I_1 e^{-j\varphi_I} = 3V_1 I_1 e^{j(\varphi_V - \varphi_I)}$$

$$P = 3V_1 I_1 \cos(\varphi_V - \varphi_I)$$

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 11.14.2 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 6.36.3.2 *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:

$$P = 3V_1 I_1 \cos(\varphi_V + \varphi_{U} - (\varphi_I + \varphi_{I,U})) = 3V_1 I_1 \cos(\varphi_V - \varphi_I + (\varphi_{VF} - \varphi_{IF}))$$

The angle error to be corrected results as:

$$\varphi_{corr} = \varphi_{IF} - \varphi_{VF}$$

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	-

6.36.3.2 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 11.14.2 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 6-17 For Phase A

V/Vn	$S_b = S_n$		$S_b = S_n/4$	
	ε_U [%]	δ_U [min]	ε_U [%]	δ_U [min]
0.8	-0.14	0.31	0.16	-0.44
1	-0.15	0.43	0.15	-0.74
1.2	-0.36	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 results.

Table 6-18 Phase A

I/I_n [%]	$S_b = S_n$ (cos β = 0.8)	
	ε_I [%]	δ_I [min]
100	0.314	46.40

Table 6-19 Phase B

I/I_n [%]	$S_b = S_n$ (cos β = 0.8)	
	ε_I [%]	δ_I [min]
100	0.247	35.10

Table 6-20 Phase C

I/I_n [%]	$S_b = S_n$ (cos β = 0.8)	
	ε_I [%]	δ_I [min]
100	0.702	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:

$$\delta_I [\text{min}] = \frac{1}{3}(\delta_{IA} + \delta_{IB} + \delta_{IC}) = \frac{1}{3}(46.40 + 35.10 + 41.10) = 40.87 \text{ min}$$

The resulting correction angle is:

$$\varphi_{corr} [\text{min}] = \varphi_{U} - \varphi_{I} = 0.43 \text{ min} - 40.87 \text{ min} = -40.44 \text{ min}$$

$$\varphi_{corr} [°] = \frac{\varphi_{corr}[\text{min}]}{60} \cdot 1° = \frac{-40.44}{60} \cdot 1° = -0.674°$$

Set the parameter `(_:2311:101) Angle correction` = -0.67°.

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Parameter: Maximum 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, Siemens recommends using the default setting.

6.36.3.3 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

6.36.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:Undervoltage blocking	SPS	O
_:2311:301	General:P1avg	MV	O
_:2311:302	General:Q1avg	MV	O
_:2311:303	General:P1fast	MV	O
_:2311:304	General:Q1fast	MV	O

6.36.4 Stage Description

6.36.4.1 Description

Logic of the Stage

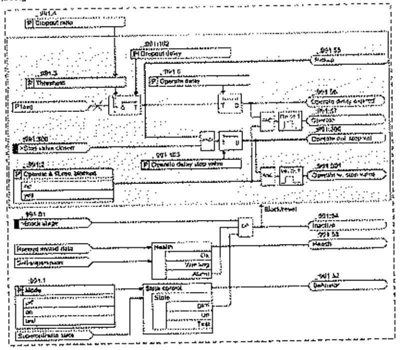

Figure 6-217 Logic Diagram of the Reverse Power Protection Stage

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.

6.36.4.2 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 ranges:

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 30.00 %

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 (P1avg). 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).

6.36.4.3 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

6.36.4.4 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

6.37 Overexcitation Protection

6.37.1 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.

6.37.2 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

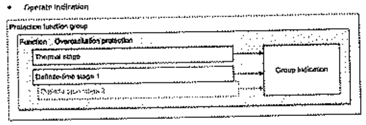

Figure 6-218 Structure/Embedding of the Function

Function Measured Value

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

6.37.3 Stage with Dependent Characteristic Curve (Thermal Stage)

6.37.3.1 Function Description

Logic

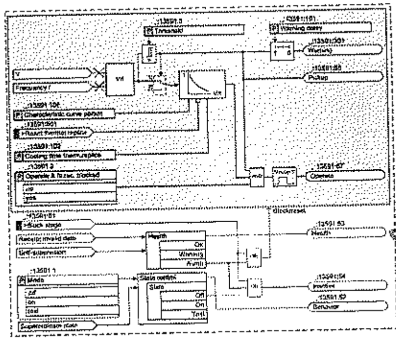

Figure 6-219 Logic of the Overexcitation Protection with Thermal Characteristic Curve

(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 6.12 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:

$$\frac{V/V_{rated,sec}}{f/f_{rated}}$$

with

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

Based on the definition above, 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 fact must be considered during a secondary test.
More information can be found in chapter 11.36 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 pre-determined 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 protection 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 as ((_: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 776).

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 pairs V/f (referring to the rated values) and operate time t can be set. The default characteristic curve refers to a standard transformer.

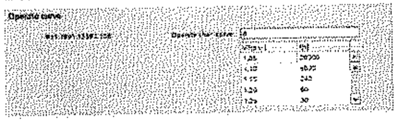

Figure 6-220 Data Sheet for Adjustment of Thermal Characteristic Curve

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 6-221).

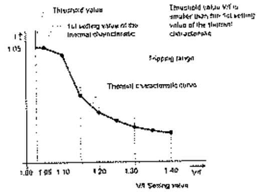

Figure 6-221 Tripping Zone of the Thermal Characteristic Curve (I)

If the Threshold is greater, then a cutoff occurs (see Figure 6-222).

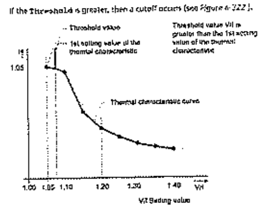

Figure 6-222 Tripping Zone of the Thermal Characteristic Curve (II)

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 invocation 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 fill level of the thermal storage will be provided as functional measured value.

Measured Value	Description
(_:13591:321) V/f th.	Thermal tripping of the overexcitation protection. If the value reaches 100 %, the tripping occurs.

Cooling Time

If the value drops below the threshold ((_:13591:3) Threshold), tripping of the thermal characteristic curve (dependent characteristic curve) is reverted. 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 (_:13591:501) >Reset thermal replica 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.

6.37.3.2 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 polling 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 curves 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 775).

6.37.3.3 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	1.40
_:13621:6	Definite-T 1:Operate delay		0.00 s to 60.00 s	1.00 s
General				
_: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 100000 s	3600 s

6.37.3.4 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

No.	Information	Data Class (Type)	Type
_: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	SFS	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

6.37.4 Stage with Independent Characteristic Curve

6.37.4.1 Function Description

Logic

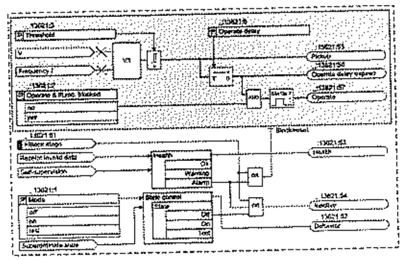

Figure 6-223 Logic of the Overexcitation Protection with Independent Characteristic Curve (Definite-time Stage)

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 6.37.3 Stage with Dependent Characteristic Curve (Thermal Stage).

How the Definite-Time Stage Works

The stage comprises 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 %.

6.37.4.2 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 acts 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.

6.37.4.3 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	1.40
_: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

6.37.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:322	General:VF	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

No.	Information	Data Class (Type)	Type
_: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

6.38 Undervoltage-Controlled Reactive-Power Protection

6.38.1 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

6.38.2 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.

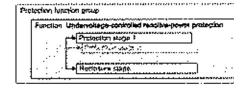

Figure 6-224 Structure/Embedding of the Function

6.38.3 Description Protection Stage

6.38.3.1 Description

Logic of the Stage

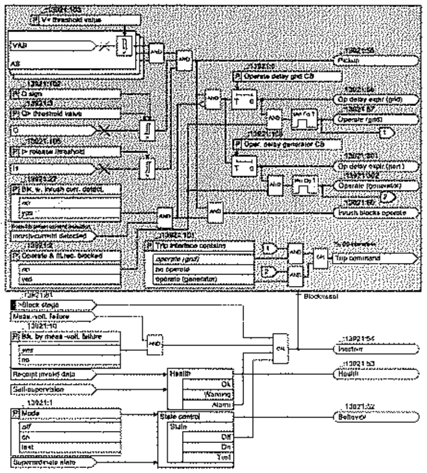

Figure 6-225 Logic Diagram of the Protection Stage of the Undervoltage Controlled Reactive-Power Protection

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

  For further information, refer to chapter 6.7.4.1 Description.

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 6.3.7.1 Description.

6.38.3.2 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.

Parameter Value	Description
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: V< threshold value

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

You use the V< 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:

$$Q_{>,setting} = 100\ V \cdot 1\ A \cdot \sqrt{3} \cdot 0.05 = 8.7\ VA$$

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: Trap 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.

6.38.3.3 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:V< 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 (G)		0.00 s to 60.00 s	0.50 s

Addr.	Parameter	C	Setting Options	Default Setting
_:13921:6	Prot. stage 1:Operate delay grid (G)		0.00 s to 60.00 s	1.50 s

6.38.3.4 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

6.38.4 Description Reclosure Stage

6.38.4.1 Description

Logic of the Stage

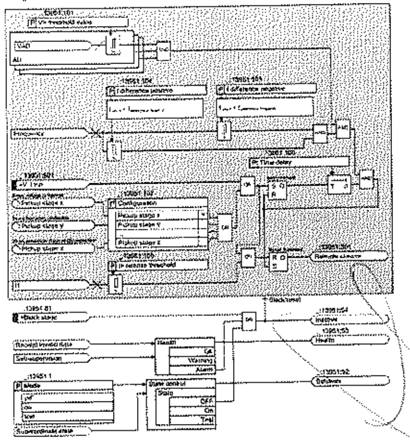

Figure 6-226 Logic Diagram of Reclosure Stage in Undervoltage-Controlled Reactive-Power Protection

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 >V, f trip, 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.

6.38.4.2 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 = 0.100 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 (_:13951:100) 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.

6.38.4.3 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	0.100 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
_:13951:100	Reclos. stage:Time delay		0.00 s to 3600.00 s	0.00 s
_:13951:102	Reclos. stage:Configuration		Setting options depend on configuration	

6.38.4.4 Information List

No.	Information	Data Class (Type)	Type
Reclos. stage			
_:13951:81	Reclos. stage:>Block stage	SPS	I
_:13951:501	Reclos. stage:>V, f trip	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

6.39 Circuit-Breaker Failure Protection

6.39.1 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.

6.39.2 Structure of the Function

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

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

Figure 6-227 Structure/Embedding of the Function

Figure 6-228 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.

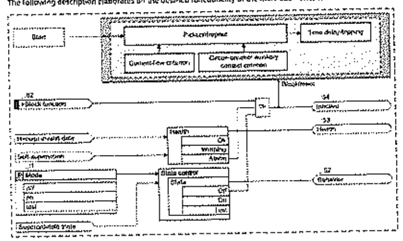

Figure 6-228 Function Logic Overview

ВЯРНО С ОРИГИНАЛА

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6.39.3 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 6-229 and Figure 6-230 show the function logic.

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 6-229) 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).

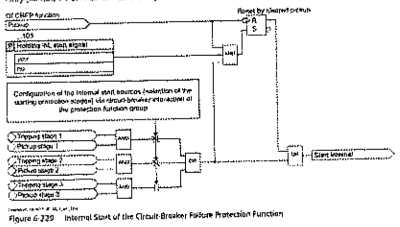

Figure 6-229 Internal Start of the Circuit-Breaker Failure Protection Function

External Start

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

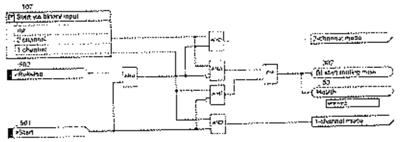

Figure 6-230 Configuration of the External Start of the Circuit-Breaker Failure Protection Function

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 6-231). If necessary, the starting signal can be held. In this case the start remains active when the binary input signals have a falling edge.

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

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

Supervision is disabled in the following cases:

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

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

The binary input signals only take effect if the binary inputs are activated for at least 10 ms (SW filter, see Figure 6-231).

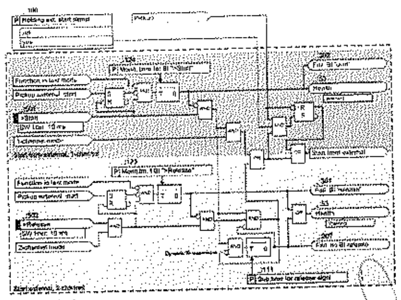

Figure 6-231 External Start of the Circuit-Breaker Failure Protection Function, Logic

Current-Flow Criterion

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

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

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

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

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

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

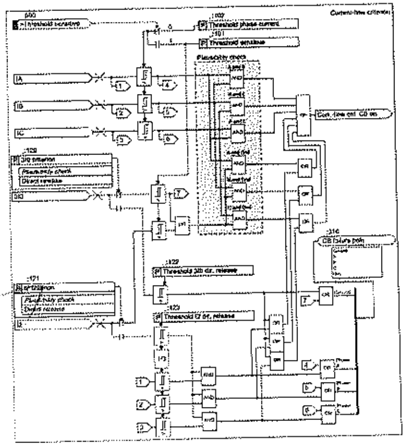

Figure 6-232 Current-Flow Criterion

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 Cl ed is disabled).

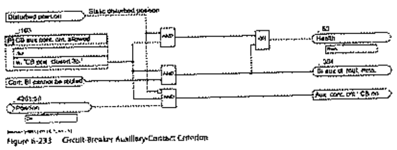

Figure 6-233 Circuit-Breaker Auxiliary-Contact Criterion

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 6-229 and Figure 6-231). 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.

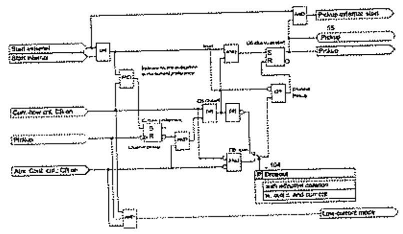

Figure 6-234 Pickup/Dropout of the Circuit-Breaker Failure Protection Function

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

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

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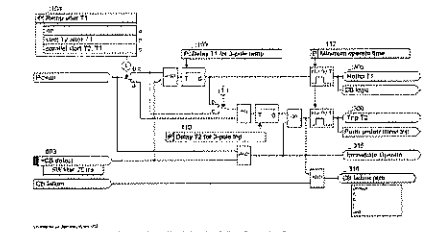

Figure 6-235 Delay/Tripping of the Circuit Breaker Failure Protection Function

6.39.4 Application and Setting Notes

Figure 6-236 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.

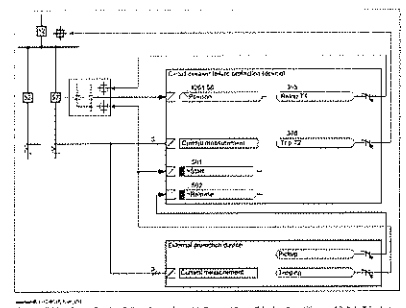

Figure 6-236 Circuit Breaker Failure Protection with External Start, Tripping Repetition and 2-Pole Tripping (T2)

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, further disconnection following a local circuit-breaker failure can be undesirable in the case of load-shedding applications or ground faults in isolated/resonant-grounded systems.

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

Parameter: Start via binary input

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

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

Parameter Value	Description
2 channel	2-channel start is used if there is a risk that the circuit-breaker failure protection causes a tripping due to a faulty activation of the start binary input. This is the case in the following situations: a) The CBFP pickup value (threshold value) is set to less than the load current. b) There can be operative 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 6-236).
>Release	The enabling input signal is normally linked with the pickup of the external protection device (see Figure 6-236). Another common configuration is the parallel wiring of the external trip initiation to both binary inputs (start and release).

Parameter: Supervision time release signal

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

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

Parameter: Holding internal signal

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

Parameter Value	Description
yes	For an internal start, the starting signal is held by default. The dropout of the CBFP depends exclusively on the determination of the CB position. This setting must be selected if it is not ensured that all 3 poles of the CB have opened when the pickup signal of the protection function has a falling edge. Siemens recommends using this method as the standard method.
no	Holding of the starting signal can be disabled if it is ensured by the application that the CB has reliably opened when the starting signal has a falling edge, or if the CBFP is explicitly required to dropout when the starting signal has a falling edge.

EXAMPLE

Holding internal starting signal (setting value: yes)

In the event of a 2-pole fault, only one contact of the CB opens. The fault current is thus reduced, and the starting phase short-circuit protection drops out.

Parameter: Holding ext. start signal

- Recommended setting value (_:106) Holding ext. start signal = no

Parameter Value	Description
no	The CBFP drops out when the external starting signal has a falling edge. This setting prevents the CBFP from generating a tripping signal when an unwanted pulse is received at the binary input and the current flow is high enough. Siemens recommends using this method as the standard method.
yes	You can hold the starting signal if it is not ensured that the circuit breaker is open when the external starting signal has a falling edge.

EXAMPLE

Holding external starting signal (setting value: yes)

The function is started from the opposite end via an auxiliary device for command transmission. This device generates only a signal pulse.

NOTE

Siemens would like to point out that, with a held signal, the CBFP generates a trip signal each time a starting pulse is received and the current flow is high enough. Remember this particularly in the case of an external start.

Parameter: Threshold phase current/Threshold sensitive

- Recommended setting value (_:102) Threshold phase current = approx. 0.50 $I_{sc,min}$
- Recommended setting value (_:101) Threshold sensitive = approx. 0.50 $I_{sc,min}$

In order to ensure that the disconnection of the fault is promptly detected and the function can drop out quickly, Siemens recommends setting both thresholds to half the minimum short circuit current ($I_{sc,min}$).

If – depending on the neutral-point treatment and/or load conditions – ground faults lead to relatively low fault currents, a sensitive setting of the parameter Threshold sensitive must be selected according to the rule (0.5 $I_{sc,min}$). There can also be values which are noticeably below the rated or load current.

Input Signal: >Threshold sensitive

In order to ensure that the function picks up reliably in all switch positions of the power-supply system (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 contacts are permitted as a further criterion in applications (see the following examples) where the current is an unreliable criterion for determining the circuit-breaker position.

Parameter: 3I0 criterion

- Recommended setting value (_:125) 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 1/3 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)	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 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 actuation 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).

6.39.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
SOBF CB fail-#				
_:1	SOBF CB fail-#:Mode		• off • on • test	on
_:105	SOBF CB fail-#:Holding int. start signal		• no • yes	yes
_:107	SOBF CB fail-#:Start via binary input		• no • 1 channel • 2 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-#:Max.t. sup. for BI ">Start"		0.05 s to 60.00 s	15.00 s
_:125	SOBF CB fail-#:Min.t. sup. for BI ">Release"		0.05 s to 60.00 s	15.00 s

6.39.6 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-#:>Thresh. ground curr.	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 aux.ct. rout. miss.	SPS	O
_:300	SOBF CB fail-#:Fail. BI "start"	SPS	O
_:307	SOBF CB fail-#:Fail. no BI release	SPS	O
_:301	SOBF CB fail-#:Fail. BI "release"	SPS	O

6.40 Circuit-Breaker Restrike Protection

6.40.1 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

6.40.2 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.

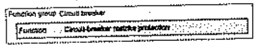

Figure 6-237 Structure/Embedding of the Function

The function logic is grouped into the parts shown in Figure 6-238. In the following chapter, these logic parts are described in detail.

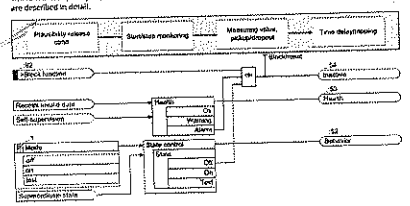

Figure 6-238 Logic Overview of the Function

6.40.3 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.

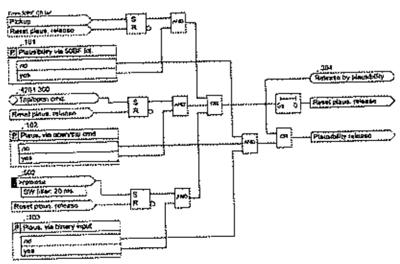

Figure 6-239 Logic Diagram for the Plausibility Release of the Circuit-Breaker Restrike Protection

The plausibility-release logic checks the following conditions:

- When the parameter Plausibility via SOBF fail. 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.

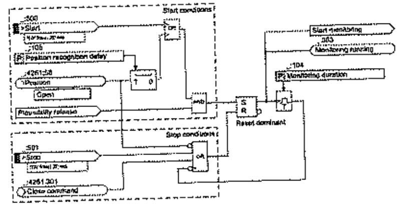

Figure 6-240 Logic Diagram for Start/Stop Monitoring of the Circuit-Breaker Restrike Protection

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 808) 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 811.

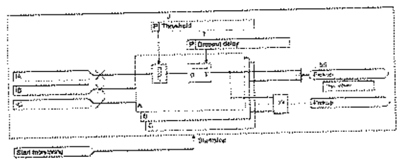

Figure 6-241 Logic Diagram for Measuring Value, Pickup/Dropout of the Circuit-Breaker Restrike Protection

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 restrikes 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**.

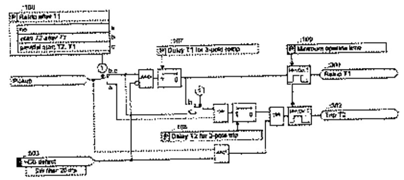

Figure 6-242 Logic Diagram for Delay/Tripping of the Circuit-Breaker Restrike Protection

6.40.4 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 protocol 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 812.
>Stop	This input signal allows to stop the monitoring, for example, via protocol 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` = 300.00 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 cause tripping. For minimizing the risk, Siemens recommends applying a release criterion additionally. Refer to Parameter: Switch On or Off Additional Plausibility Release Criteria, Page 812.

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. 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 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 superordinated 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 (_:109) `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 (_:199) `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 T1*

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 *Position*) is routed.

If a second control circuit is present, the *Retrip T1* 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.

6.40.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Restrike prt.#				
_:1	Restrike prt.#:Mode		• off • on • test	off
_:101	Restrike prt.#:Plausibility via SOBF 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.#:Position 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

6.40.6 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.#:>release	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
_:303	Restrike prt.#:Monitoring running	SPS	O
_:55	Restrike prt.#:Pickup	ACD	O
_:301	Restrike prt.#:Retrip T1	ACT	O
_:302	Restrike prt.#:Trip T2	ACT	O

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6.41 Restricted Ground-Fault Protection

6.41.1 Overview of Functions

The Restricted ground-fault protection function (ANSI 87N):

- Detects ground faults in transformers, shunt reactors, neutral reactors or rotating machinery in which the neutral point is grounded
- Has high sensitivity to ground faults near the neutral point
- Is supplemental main protection to longitudinal differential protection
- Protects grounding transformers in the protection range. It is required that a current transformer be used in the case of neutral-point feed, that is, between neutral point and grounding conductor. The neutral-point transformer and the phase current transformer define the protection range
- Adapts itself to the highest amperage side with auto transformers and thereby prevents overfunction in the event of external ground faults.

6.41.2 Structure of the Function

The Restricted ground-fault protection function is used in the Transformer side or Auto transformer protection function group. Furthermore, you can use the function in the stabilizing winding of the auto transformer or also in the Standard LI function. The function depends upon application in the corresponding application template preconfigured by the manufacturer or can be copied during the engineering into the corresponding function group.

The Restricted ground-fault protection function is stateless.

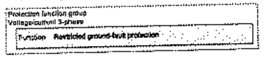

Figure 6-243 Structure/Embedding of the Function

6.41.3 Function Description

Logic of the Function

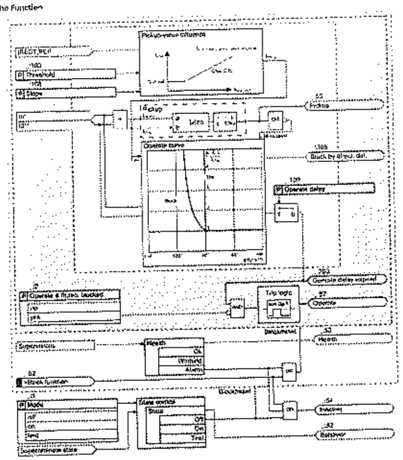

Figure 6-244 Logic Diagram of the Restricted Ground-Fault Protection Function

The protection function processes the neutral-point current I_0^* (exactly $3I_0'$) and the calculated zero-sequence current I_0^{**} (exactly $3I_0''$) from the phase currents (see following figure). The protection range extends exclusively over the transformer winding, including current transformer. The amount adapted (compensated) currents are described by the * icon. They are normalized to the rated object current of the respective side. In case of an internal ground fault, the residual currents flow to the fault location. With an external ground fault, the fault current inverts itself in the phase current transformers. In this way, the direction of current flow serves as the decisive criterion for an internal fault.

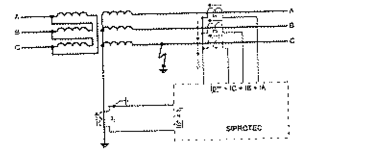

Figure 6-245 Basic Principle of the Function

In accordance with the logic diagram, Figure 6-244 the protection function consists of 3 parts:

Effect of Pickup Value

The differential current and the restraint current are calculated from the residual currents. The reference arrows are defined as positive when pointing to the protected object (see Figure 6-245). Consider that the ground current in the fault record and in the DIGSI 4 Test Suite are displayed as positive if the current flows to ground from the protected object.

> **NOTE**
>
> The following calculation applies to the configurations with a current transformer for the side. In a special case of several current transformers per side, the calculation of the restraint current must be performed in greater detail.

$I_0^* = k_{tr} \cdot 3I_0'$

$I_0^{**} = k_{tr} \cdot 3I_0'' = I_A + I_B + I_C$

with $k_{tr} = I_{prim,transf}/I_{rated}$

$I_{diff,REF} = |I_0^* + I_0^{**}|$

$I_{rest,REF} = |I_0^*| + |I_A| + |I_B| + |I_C|$

where:

$3I_0'$	Measured zero-sequence current at neutral point
$3I_0''$	Zero-sequence current calculated from the phase currents
k_{tr}	Factor for amount adaptation (compensation)
$I_{prim,transf}$	Primary transformer rated current
I_{rated}	Primary rated current of the transformer side
$I_{diff,REF}$	Differential current
$I_{rest,REF}$	Restraint current

Using the calculated restraint current, a current $I_{Threshold}$ which represents the pickup value for the tripping is determined from the characteristic curve (Figure 6-246). In this way, the protection function is stabilized in the event of external, multiphase ground faults, for example, a 2-pole ground fault. This means that the protection function becomes less sensitive.

If the Slope = 0 is set here, the set Threshold of the operate curve is delivered independent of the restraint current.

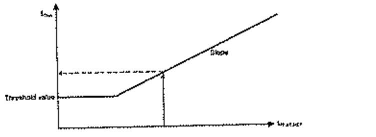

Figure 6-246 Stabilized Characteristic Curve

Processing a Ground Side for Auto Transformer

Instead of a 1-phase neutral point, with an auto transformer a 3-phase ground side can also be used.

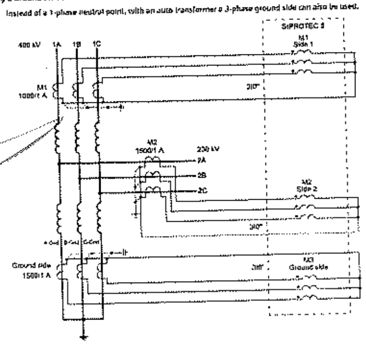

Figure 6-247 Connecting a Ground Side on the Auto Transformer

In this case the neutral-point current calculates as sum of the phase currents of the ground side:

$I_0^* = k_{tr} \cdot 3I_0' = 3I_0' = I_{gnd,A} + I_{gnd,B} + I_{gnd,C}$

with $k_{tr} = I_{prim,transf}/I_{rated}$

The following applies for the restraint current:

The following applies for the restraint current: $I_{rest,REF} = |I_{gnd,A}| + |I_{gnd,B}| + |I_{gnd,C}| + |I_A| + |I_B| + |I_C|$

> **NOTE**
>
> If both 1-phase neutral point and 3-phase ground side are connected, only the 1-phase neutral point is used by the restricted ground-fault protection. The 3-phase ground side is not considered.

Pickup

If the $I_{diff,REF}$ calculated differential current exceeds the $I_{Threshold}$ calculated current (see Figure 6-244), pickup occurs and the internal processing is enabled. The pickup is indicated.

Operate Curve

The operate curve represented in the following figure consists of 2 parts. In the right part of the characteristic curve, you will find a case of an internal ground fault. Under ideal conditions, the angle between the two residual currents ($\angle(I_0^*, I_0^{**})$) equals 0. With current-transformer saturation, angle errors can result. The right part of the characteristic curve is valid for angles ≤ 90°. The tripping current is the current flowing at the neutral point (I_0^*). It is compared to the set or increased threshold value.

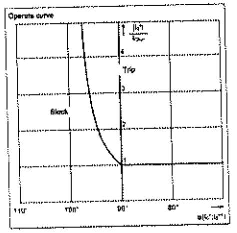

Figure 6-248 Operate Curve Depending on the Phase Angle between I_0^* and I_0^{**} at $|I_0^*| = |I_0^{**}|$ (180° = External Fault)

In case of an external ground fault the zero-sequence current calculated from the phase currents reverses by 180°. The phase angle between the residual currents thus ($\angle(I_0^*, I_0^{**})$) equals 180°. They are located in the left part of the operate curve and recognize a clearly increased pickup value. Angle deviations of 180° are caused by transformer saturation in conjunction with external short-circuits.

The current $I_{angle,dec}$ for the **Angle Decision** is determined from the following subtraction and summation:

$I_{angle,dec} = |I_0^* - I_0^{**}| - |I_0^* + I_0^{**}|$

The resulting current $I_{angle,dec}$ results from the respective fault conditions, which are illustrated in the following figure. With an internal fault (angle = 0°), a current results that has a negative sign. If angle errors occur, the sign remains negative. The amount of the current decreases.

In an external short-circuit (180°), the current becomes positive. At a smaller angle (<180°) due to transformer saturation, the angle remains positive. The amount also decreases.

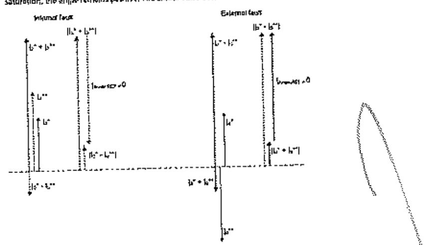

Figure 6-249 Angle Decision in Internal and External Faults

For tripping to occur, the neutral-point current I_0^* must reach the value $I_{diff,ext}$. The characteristic curve in the left part of the figure can be determined from the following relationship:

$I_{diff,ext} = I_{Threshold} + k \cdot I_{angle,dec}$

where:

$I_{Threshold}$	Pickup value resulting from the pickup value increase
k	Factor (permanently set to 4.0, 5667. With this value, the limit angle at $|I_0^*| = |I_0^{**}|$ is precisely 100°. No tripping is possible from this angle on.)

Processing of Several Measuring Points on One Side

If several measuring points are present on one side of a star winding, as with a 1 1/2 circuit-breaker application, the angle decision occurs separately for each measuring point. The maximum current $I_{angle,dec}$ is used to establish the tripping decision.

> **NOTE**
>
> With an external fault, the current $I_{angle,dec}$ is always > 0.

The following figure shows the behavior under different fault conditions.

Also observe that the restraint current ($I_{rest,REF}$) always results from the sum of all currents (phase currents of the measuring points and the neutral-point current). For pickup, the differential current $I_{diff,REF}$ is necessary. This differential current results from the geometric sum of all adapted residual currents. The residual currents of the measuring points on the outgoing side and of the neutral-point current are meant here.

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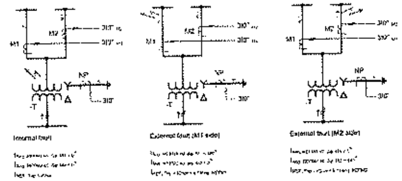


Figure 6-250 Behavior under Different Fault Conditions

Functional Measured Values

Measured Value	Description
(_:306) I REF,operate	Operate quantity of the restricted ground-fault protection from the angle criterion
(_:307) I Angle,REF	Stabilizing value (angle) of the restricted ground-fault protection from the angle criterion
(_: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

You will find the measured values for the **Restricted ground-fault protection** under the following device menu entries:

- Main menu → Measurements → function → Function values → 87N REF

6.41.4 Application and Setting Notes

NOTE

The following conditions must be observed when setting the threshold values:

Threshold value ≥ max (0.05 I/Irated,S; 0.05 I/Irated,S · I_prim transf. max / I_rated, protected object)

Threshold value ≤ min (2.00 I/Irated,S; 100.00 I/Irated,S · I_prim transf. min / I_rated, protected object)

The value 0.05 I/Irated,S is the minimum possible setting value and 2.00 I/Irated,S the maximum possible. I_transformer,max is the largest transformer current and I_rated,protected object the protected object rated current. 100.00 I/Irated,S is the upper measurement limit.

If otherwise it could happen that there is chattering of the pickup indication, the minimum threshold limit is lifted. The maximum limit on the other hand is corrected downward, if the exceeding current otherwise through the magnitude scaling must be so large, that it would already be outside of the measuring range of the transformer.

The adaptation of the setting limits is done automatically. In addition a setting is prevented outside of these limits.

In the following, typical applications are described for the restricted ground-fault protection.

Protection of a Solidly Grounded Star Winding (Y Side)

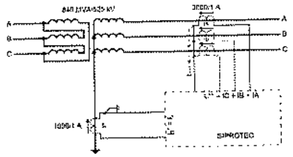


Figure 6-251 Application Star Side

This application is a standard application. Here the phase currents of one side and the neutral-point current are processed. The function is located in the Transformer Side function group.

The following figure show the structural division of the function. The restricted ground-fault protection gets its measurands from the current transformers, which are connected to the Transformer side function group. The neutral-point current is guided via the Transformer neutral point function group to the Transformer side function group. To be compatible with SIPROTEC 4 (including reference arrow definition of the restricted ground-fault protection), in addition to the magnitude scaling of the neutral-point current, a rotation of the polarity (phase rotation by 180°) is also done in the Transformer neutral point function group.

NOTE

The fault record indicates the analog traces according to the connection. For this reason the neutral-point current is shown rotated by 180° in comparison to SIPROTEC 4.

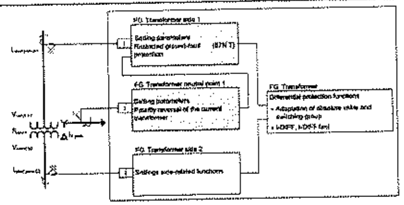
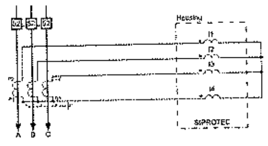


Figure 6-252 Function Group Structure of the Restricted Ground-Fault Protection

Explanations on the Connection and Current-Direction Definition

Uniform reference arrows and transformer polarities are defined for the SIPROTEC 5 device series. These agreements also apply to the transformer protection devices. The special handling of the neutral-point current described previously is a result of this.

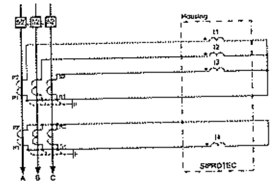
The current definition states that the sum of the currents flowing into the protected object is equal to 0 ($I_A + I_B + I_C + I_N = 0$ or $I_A + I_B + I_C = -I_N$). The protected object is located to the right or left of the transformer set. The following basic connections result from this.



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

Figure 6-253 Current Transformer Connection (1) According to Definition

or



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

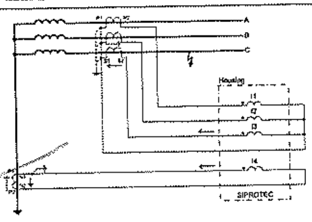
Figure 6-254 Current-Transformer Connection (2) According to Definition

The following connection is defined for the transformer according to Figure 6-255. The current flow for an external ground fault is entered at the same time. It is recognized that the secondary currents each flow from the device. From this, a differential current ($I_{diff,REF} = |I_A + I_B + I_C + I_N| = |-I_N - I_N|$) results, according to the reference arrow definition for the restricted ground-fault protection (positive to the protected object) with an

external ground fault. To prevent that, the neutral-point current is rotated in the Transformer neutral-point function group. It follows that: $I_{diff,REF} = |I_N - I_N| = 0$.

NOTE

If the neutral-point current is included in the protection function (zero-sequence current correction), this rotation also has an effect for the differential protection.



Current transformer 3-phase, connection = 3-phase

Current transformer 1-phase, connection = IN

Figure 6-255 Current Transformer Connection on the Transformer

The setting of the 1-phase measuring point based on the definition is done as follows:

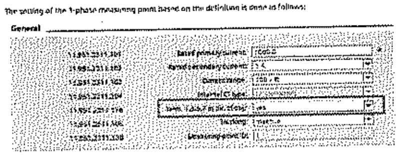


Figure 6-256 DIGSI 5 Setting

The point in Figure 6-255 describes the polarity of the current transformer. At the same time the current terminal is designed so that this side is fed out on an odd number terminal point. Since in the SIPROTEC 5 system each current transformer can be assigned a 1-phase measuring point, the odd number terminal points are named in the setting parameters. According to Figure 6-255 the setting must be yes.

- Default setting (_:115) terminal 1,3,5,7 in dir.obj. = yes

The following view can be used to derive the threshold value. The transformer is supplied, for example, via the delta winding and a 1-pole ground fault occurs on the star side.

NOTE

For estimation of the short-circuit current, note that the inductance changes quadratically with the winding and the linearly with the voltage.

The right part in the following figure represents the fault current as a function of the fault location. The fault current curve I_F shows that the longitudinal differential protection with faults near the neutral point has sensitivity problems due to the sinking current. On the other hand, the neutral-point current I_{SP} is sufficiently large. There is therefore no need to set the Threshold (current through the neutral point transformer) to sensitive.

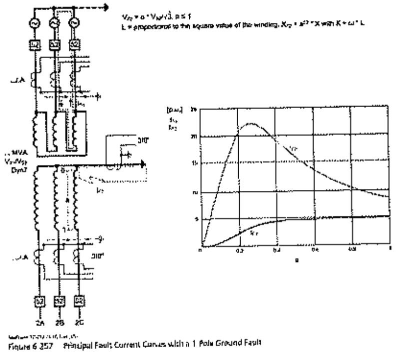


Figure 6-257 Principal Fault Current Curves with a 1-Pole Ground Fault

- Recommended setting value (_:103) Threshold = 0.2 I/Irated,S

The previously mentioned condition must be maintained during the setting.

$$\text{Threshold value} \geq 0.05\ \text{Irated,S} \cdot \frac{I_{CT,max,prim}}{I_{rated,obj}}$$

The following lower limiting value results from the data from Figure 6-251:

$$\text{Threshold value} \geq 0.05\ \text{Irated,S} \cdot \frac{3000\,A}{924\,A} = 0.162\ \text{Irated,S}$$

$$\text{with } I_{rated,side} = \frac{S_{rated}}{\sqrt{3}\,V_{rated}} = \frac{840\,MVA}{\sqrt{3}\,625\,kV} = 924\,A$$

The recommended setting value of 0.2 I/Irated,S lies above it.

- Recommended setting value (_:105) Slope = 0.07

You can stabilize the protection function (less sensitive setting) with external multiphase short-circuits to ground with the parameter Slope. To determine the setting value, no pickup value increase can occur up to the rated current. After this, the gradient must be active. To derive the gradient, it is assumed that continuation of the straight line must go through the coordinate origin (see Figure 6-258). Determine the intersection from the threshold value and the restraint current at rated current. Calculate the gradient as follows:

$$I_{rest,REF} = |I_N| + |I_A| + |I_B| + |I_C| = 0 + 3\ \text{Irated,S} = 3\ \text{Irated,S}$$

$$\text{Slope} = \frac{\text{Threshold value}}{I_{rest,REF}} = \frac{0.2\ \text{Irated,S}}{3\ \text{Irated,S}} = 0.07$$

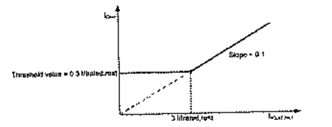


Figure 6-258 Derivation of the Setting Value for the Gradient

If you have several measuring points on an outgoing side (see Figure 6-250), Siemens recommends using the value 3 Irated,S in the intersection calculation for the restraint current. In the load case, the maximum transformer rated current flows on one side.

If, however, several measuring points are on the supply side (for example, breaker-and-a-half layout), Siemens recommends including all phase currents in the intersection calculation, in order to avoid too strong of a stabilization. With 2 measuring points, a value of 6 Irated,S results as intersection with the threshold value. The slope becomes flatter (0.2 Irated,S/6 Irated,S = 0.03).

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Protection of an Auto Transformer

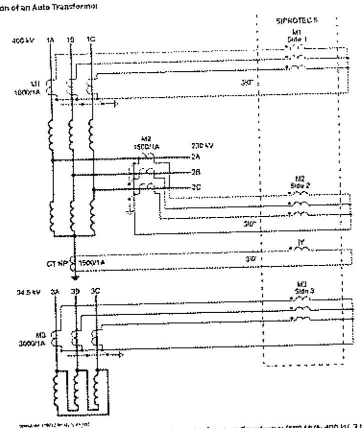

Figure 6-259 Activation and Application Example of an Auto Transformer (500 MVA; 400 kV, 230 kV; 125 MVA; 34.5 kV)

Use the highest side rated current with the auto transformer for normalization. In the example (Figure 6-259), the measuring point is M2 (230 kV side). For this side, a rated current of 500 MVA/(√3 · 230 kV) = 1255 A results. The primary transformer rated current is 1500 A. With this, you can estimate the minimum permissible pickup value.

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{I_{CT\ starpoint}}{I_{object\ side}} = 0.05\ I/I_{rated,S} \cdot \frac{1500\,A}{1255\,A} = 0.06\ I/I_{rated,S}$$

Siemens recommends a setting value of 0.2 I/Irated,S.

- Recommended setting value (_:103) `Threshold = 0.2 I/Irated,S`

To determine the `Slope`, the restraint current of both sides (400 kV and 230 kV) must be used. The rated current is used as starting value for the gradient. Since side 2 (230 kV) is the reference side for the normalization, the value of the 400 kV side must be adapted to this rated current. The adaptation factor results from the inverse ratio (230 kV/400 kV). The following restraint current goes into the calculation.

$$I_{restREF} = 3\ I/I_{rated,S2} + 3\,\frac{230\,kV}{400\,kV}\ I/I_{rated,S2} = 3\ I/I_{rated,S2} + 1.725\ I/I_{rated,S2} = 4.73\ I/I_{rated,S}$$

$$\text{Slope} = \frac{\text{Threshold value}}{I_{restREF}} = \frac{0.2\ I/I_{rated,S}}{4.73\ I/I_{rated,S}} = 0.042$$

Siemens recommends using the setting 0.07

- Recommended setting value (_:105) `Slope = 0.07`

Protection of a Resistance-Grounded Star Winding (Y Side)

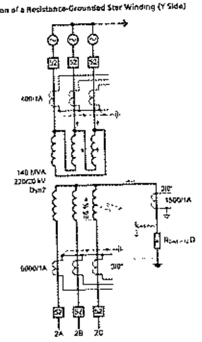

Figure 6-260 Application with Resistance-Grounded Neutral Point

To also capture faults in the resistance to ground, a current transformer must be installed at the neutral point of the protected object (see Figure 6-260). The pickup values can be derived from the data in the example. As side rated value, the following results:

140 MVA/(√3 · 20 kV) = 4042 A

The following threshold value results as lower limit:

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{6000\,A}{4042\,A} = 0.07422\ I/I_{rated,S}$$

$$\text{with } I_{object\ side} = \frac{S_{rated}}{\sqrt{3} \cdot V_{rated}} = \frac{840\,MVA}{\sqrt{3} \cdot 525\,kV} = 924\,A$$

So that the function is responsive, select a setting value of 0.08 I/Irated,S.

- Recommended setting value (_:103) `Threshold = 0.08 I/Irated,S`

As gradient, the following results.

$$\text{Slope} = \frac{\text{Threshold value}}{I_{restREF}} = \frac{0.08\ I/I_{rated,S}}{3\ I/I_{rated,S}} = 0.03$$

- Recommended setting value (_:105) `Slope = 0.03`

Because of the grounding resistance R, reduced protection range results. This can be estimated as follows. The grounding resistance is much larger than the winding reactance, thus the following maximum ground current results:

I_{Gndmax} = 20 kV/(√3 · 12 Ω) = 962 A

You can determine the minimum tripping current from the setting value.

I_{Gndmin} = side rated current * threshold value = 4042 A · 0.08 = 323 A

Thus, the following protection range results:

$$\text{Protection range} = 1 - \frac{I_{Gnd\,min}}{I_{Gnd\,max}} = 1 - \frac{323\,A}{962\,A} = 0.664$$

The attainable protection range amounts to approx. 66.4 %. In order to capture ground faults near the neutral point, it is also recommended to connect a sensitive ground current protection to the neutral point transformer. You must coordinate its operate time with the line protection.

> **NOTE**
>
> Ensure that the protection range further limits itself with larger neutral-point resistances, or the restricted ground-fault protection can no longer be used.

Protection with Neutral Reactors on the Delta Side

To produce ground currents on the delta side of a transformer, neutral reactors (zigzag reactors) are used. A resistance for ground current limitation can also be present. In this case, the resistance is much greater than the reactor and delta reactance of the transformer. The following figure shows a typical implementation. The restricted ground-fault protection works between output-sided phase current transformers and the current transformer in the neutral point of the neutral reactor.

In the example, the fault current curve with the ground fault in a delta winding is also represented. The fault location in which the lowest fault current flows can also be seen. This current influences the protection setting set close.

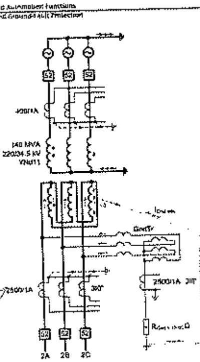

Figure 6-261 Application with Neutral Reactor

As side rated value, the following results:

140 MVA/(√3 · 34.4 kV) = 2343 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{2500\,A}{2343\,A} = 0.08\ I/I_{rated,S}$$

If the fault is in the middle of the winding, the minimum ground current will arise, as shown in Figure 6-261. The driving voltage is:

$V_{Gnd\,min} = V_{rated}/(2\sqrt{3})$ = 34.5 kV/(2 √3) = 9.96 kV

The following minimum ground current results:

$I_{Gnd\,min} = V_{Gnd\,min}/R_{Gnd}$ = 9.96 kV/19.05 Ω = 523 A

With reference to the side rated current, the relationship is:

$I_{Gnd\,min}/I_{rated,S}$ = 523 A/2343 A = 0.223

With a safety margin of 2, 0.223/2 = 0.1115 results. Select this value as threshold value (rounded: 0.12 I/Irated,S).

- Recommended setting value (_:103) `Threshold = 0.12 I/Irated,S`

As gradient, the following results:

$$\text{Slope} = \frac{\text{Threshold value}}{I_{restREF}} = \frac{0.12\ I/I_{rated,S}}{3\ I/I_{rated,S}} = 0.04$$

- Recommended setting value (_:105) `Slope = 0.04`

Protection of a Shunt Reactor

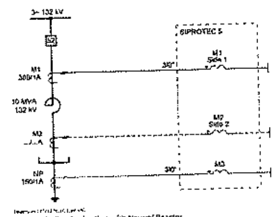

Figure 6-262 Application with Neutral Reactor

As side rated value, the following results:

10 MVA/(√3 · 132 kV) = 43.7 A

You can thus define the lower limit for the threshold value:

$$\text{Threshold value} \geq 0.05\ I/I_{rated,S} \cdot \frac{300\,A}{43.7\,A} = 0.343\ I/I_{rated,S}$$

Select 0.35 I/Irated,S as threshold value.

- Recommended setting value (_:103) `Threshold = 0.35 I/Irated,S`

For the shunt reactor, there is no external fault that can lead to overfunction. Siemens recommends a minimum rise (0.05).

- Recommended setting value (_:105) `Slope = 0.05`

6.41.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
87N REF #				
_:1	87N REF #:Mode		• off • on • test	off
_:2	87N REF #:Operate & flt.rec. blocked		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:103	87N REF #:Threshold		0.05 I/rOhm to 2.00 I/rOhm	0.20 I/rOhm
_:105	87N REF #:Slope		0.00 to 0.95	0.07
_:109	87N REF #:Operate delay		0.00 s to 60.00 s; ∞	0.00 s
_:191	87N REF #:Reference side is		• not assigned • Side 1 • Side 2 • Side 3 • Side 4 • Side 5	not assigned

6.41.6 Information List

No.	Information	Data Class (Type)	Type
87N REF #			
_:82	87N REF #:>Block function	SPS	I
_:54	87N REF #:Inactive	SPS	O
_:52	87N REF #:Behavior	ENS	O
_:53	87N REF #:Health	ENS	O
_:55	87N REF #:Pickup	ACD	O
_:57	87N REF #:Operate	ACT	O
_:303	87N REF #:Operate delay expired	ACT	O
_:305	87N REF #:Block by direct. det.	SPS	O
_:306	87N REF #:I REF,operate	MV	O
_:307	87N REF #:Angle,REF	MV	O
_:311	87N REF #:I REF,Trip operate	MV	O
_:312	87N REF #:I angle,REF operate	MV	O
_:301	87N REF #:I diff.	MV	O
_:302	87N REF #:I restr.	MV	O

ВЯРНО С ОРИГИНАЛА

6.42 External Trip Initiation 3-Pole

6.42.1 Overview of Functions

The External trip initiation function:

- Processes any signals from external protection or supervision devices
- Enables the integration of any signals from external protection equipment in the indication and tripping processing, for example from transient ground-fault relays or Buchholz protection
- Enables direct tripping of the circuit breaker in conjunction with busbar-protection applications
- Enables direct tripping of the circuit-breaker in the case of circuit-breaker failure at the other line end

6.42.2 Structure of the Function

The External trip initiation function contains one stage. The External trip initiation function can be instantiated in DIGSI 5 multiple times.

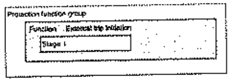

Figure 6-263 Structure/Embedding of the Function

6.42.3 Stage Description

Logic of the Stage

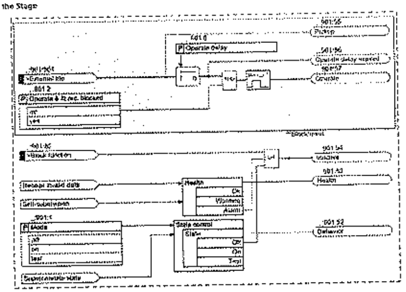

Figure 6-264 Logic Diagram for the External Trip-Initiation Stage

Binary Input Signal >External Trip

The binary input signal `>External trip` starts the `Pickup` and the `Operate delay`.

Blocking the Stage

The stage can be switched to ineffective via a number of signals. If the stage is in the pickup state at the time of blocking, it will be immediately reset. However, the operate indication remains stopped for the minimum operating time (_:102) `Minimum operate time`.

6.42.4 Application and Setting Notes

Parameter: Operate delay

- Recommended setting value (_:901:6) `Operate delay = 0.05 s`

The `Operate delay` parameter must be set for the specific application. After expiry of the `Operate delay` the time expiry and tripping are signaled. The duration of the initiation signal as well as the adjustable minimum command time determine the signal duration of the `Operate`.

6.42.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Stage 1				
_:901:1	Stage 1:Mode		• off • on • test	off
_:901:2	Stage 1:Operate & flt.rec. blocked		• no • yes	no
_:901:6	Stage 1:Operate delay		0.00 s to 60.00 s	0.05 s

6.42.6 Information List

No.	Information	Data Class (Type)	Type
Stage 1			
_:901:82	Stage 1:>Block function	SPS	I
_:901:501	Stage 1:>External trip	SPS	I
_:901:54	Stage 1:Inactive	SPS	O
_:901:52	Stage 1:Behavior	ENS	O
_:901:53	Stage 1:Health	ENS	O
_:901:55	Stage 1:Pickup	ACD	O
_:901:56	Stage 1:Operate delay expired	ACT	O
_:901:57	Stage 1:Operate	ACT	O

6.43 Automatic Reclosing Function

6.43.1 Overview of Functions

The Automatic reclosing function:

- Automatically closes overhead lines after arc short-circuits
- Is only permissible for overhead lines, because only the possibility of self-activated extinguishing of an arc short-circuit exists here
- Can be controlled by integrated protection functions and by external protection devices
- The automatic reclosing can occur through an external automatic reclosing function via binary inputs.

The automatic reclosing after switching off through a short-circuit protection is taken over by the automatic reclosing function (AREC). The following figure shows an example for the normal procedure with a two-time automatic reclosing where the second automatic reclosing attempt is successful.

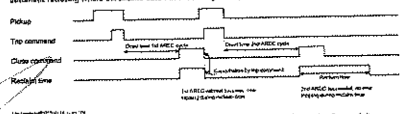

Figure 6-265 Process Diagram of a Two-Time Reclosing With Action Time (2nd Reclosing Successful)

The integrated Automatic reclosing function allows for up to 8 reclosing attempts. Each of the 8 disruption cycles can work with different parameters.

6.43.2 Structure of the Function

The automatic reclosing function is used in function groups for circuit breakers. In a function group for circuit breakers, one of the 3 types of functions illustrated in the following figures can be used. The Automatic reclosing function has a central function control.

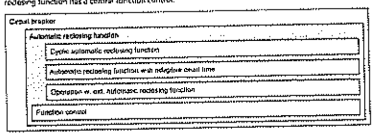

Figure 6-266 Structure/Embedding of the Function

Cyclic Automatic Reclosing Function

The Cyclic automatic reclosing function (Figure 6-267) allows for up to 8 reclosing attempts. Here each disruption cycle may work with different settings.

For the Cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete additional cycles from the function library in DIGSI 5.

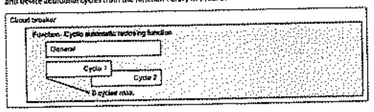

Figure 6-267 Structure/Embedding of the Cyclic Automatic Reclosing Function

Automatic Reclosing Function with Adaptive Dead Time

The Automatic reclosing function with adaptive dead time (ADT) works without fixed disruption cycles (Figure 6-268). The requirement for the usage of ADT is that voltage transformers on the line-side are connected or there is a possibility to transfer a close command to a remote line end. With the ADT, the Automatic reclosing function decides independently if and when an automatic reclosing is reasonable and permissible and when it is not. The criteria is the phase-to-ground voltage, which is switched through after reclosing from the opposite line end. The Automatic reclosing function with ADT occurs as soon as it is known that the line from the opposite end has been placed back under voltage.

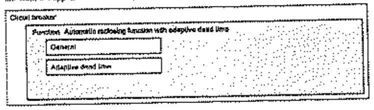

Figure 6-268 Structure/Embedding of the Automatic Reclosing Function With Adaptive Dead Time (ADT)

Operation with External Automatic Reclosing Function

The cooperation of an external reclosing device with the SIPROTEC protection device occurs through the function mode **Operation with external automatic reclosing function** (Figure 6-269). The function only provides binary inputs for the influence of the protection functions in the SIPROTEC protection device. The external automatic reclosing device delivers the close command, the SIPROTEC protection functions then provide for the trip commands.

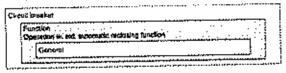

Figure 6-269 Structure/Embedding of the Operating Function With External Automatic Reclosing Function

Function Control

The automatic reclosing function contains a central function control, see the following figure. You can find detailed information on the function control in the section Function/Stage Control.

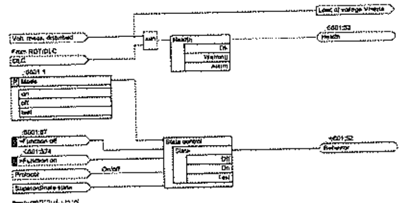

Figure 6-270 Function Control for the Automatic Reclosing Function

6.43.3 Cooperation of the Automatic Reclosing Function and Protection Functions

The Automatic reclosing function (AREC) can be influenced by the protection functions in the following way:

- The AREC is started through pickup indications and operate indications by the selected protection functions or protection stages. The start is independent of the set operating mode for the AREC.
- Individual protection functions or protection stages can be configured so that their operate indication blocks the AREC. If such a blocking exists, the AREC cannot be started. If the AREC is already started, the blocking will lead to the cancellation of the AREC.

The automatic reclosing device can thus have an influence on the effects of the protection functions. The following influence possibilities exist:

- The AREC provides signals that can be used by protection functions for the blocking or release of special stages or zones. An example is the release of overreaching zones with distance protection.

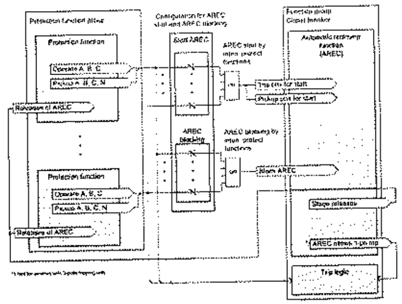

Figure 6-271 Signals between Protection Functions and Automatic Reclosing Functions

The configuration of the interaction between internal protection functions and automatic reclosing functions can be set separately for each protection function, see Figure 6-271. The configuration occurs in a matrix view in DIGSI, see the following figure.

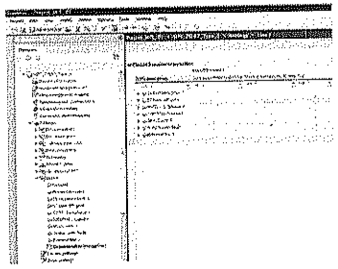

Figure 6-272 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI 5

If a protection function or the stage of a protection function is connected with the AREC through the matrix, this means that the respective pickup and operate indications are forwarded to the AREC.

The links can be conducted separately

- For starting the automatic reclosing function and
- For the blocking of the automatic reclosing function

The Automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal Automatic reclosing function.

6.43.4 Cyclic Automatic Reclosing Function

6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function

For the cyclic automatic reclosing function, there are 4 operating modes, from which one can be selected for the parametrization (parameter (_:6601:101) Operating mode).

The selection of the operating mode is dependent on the tripping behavior of the protection functions and the circuit breaker.

For applications with 3-pole tripping, all 4 operating modes are available.

- Operating mode 1: with op., with act. time
- Operating mode 2: w. pickup, w. action time
- Operating mode 3: with op., w/o act. time
- Operating mode 4: w. pickup, w/o act. time

Operating Mode 1: with op., with act. time

The operating mode with op., with act. time allows different automatic reclosing cycles depending on the tripping type and operate time of the protection function(s). With this operating mode, the automatic reclosing must be started with the operate indications. Additionally, the general pickup must also be considered.

With raising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup >Gen. pickup for start.

Through the time between the raising general pickup and clearing operate indication, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example in Figure 6-273 shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Cycle 2 is now active.

Within the following reclaim time, there will be another pickup and tripping. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The 2nd operate indication comes during the running action time of cycle 3. Thus, cycle 3 is now active.

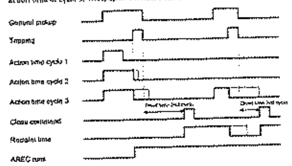

Figure 6-273 Operating-Mode Signal Examples: With Tripping/With Action Time

Through the action time, there is a direct influence on the dead time behavior of the automatic reclosing function. With faults with short operate times, other dead times can be realized than for removed faults with longer tripping time. With faults with short operate time, an automatic reclosing is executed, with removed faults this does not occur with longer operate time. The operating mode with op., with act. time allows for different automatic reclosing cycles depending on the operate time of the protection function(s).

Operating Mode 2: w. pickup, w. action time

The operating mode w. pickup, w. action time allows different automatic reclosing cycles depending on the operate time and type of fault. It is only suitable and applicable for applications with 3-pole tripping.

With this operating mode, the automatic reclosing must be started with the operate indications from the protection functions. Additionally, the pickup sample from the conductor pickups and the general pickup are considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples phase-to-ground and only grounding.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup.

With raising general pickup, the action times of the configured automatic reclosing cycles start. The general pickup is in this connection the group indication of all internal protection functions configured for starting the automatic reclosing and the external binary input for general pickup >Gen. pickup for start.

Through the time between the raising general pickup and raising trip command, the automatic reclosing cycle to be started will be determined. Here for multiple automatic reclosing cycles, the sequence of the expiring automatic reclosing cycles is not fixed, like the operating modes without action time.

The following example shows a tripping that comes after expiration of the action time of cycle 1, but still before the expiration of the action times from cycle 2 and cycle 3. Since it is a 2-phase pickup, cycle 2 is active with the dead time setting for 2-phase faults.

After reclosing, there will be another, this time 3-phase, pickup and tripping within the following reclaim time. Since cycle 2 is already complete, these and all lower cycles are no longer able to expire. The trip command comes during the current action time of cycle 3. Thus, cycle 3 is active, with the dead time setting for 3-phase faults.

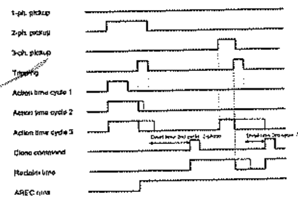

Figure 6-274 Operating-Mode Signal Examples: With Pickup/With Action Time

Operating Mode 3: with op., w/o act. time

With the operating mode with op., w/o act. time, the respective dead time is started after each trip command. The pickups are not considered. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, and 3.).

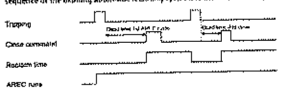

Figure 6-275 Operating-Mode Signal Examples, With Tripping/Without Action Time

Operating Mode 4: w. pickup, w/o act. time

With the operating mode w. pickup, w/o act. time, the automatic reclosing must be started with the operate indications from the protection functions. It is only suitable and applicable for applications with 3-pole tripping.

The start of the dead time occurs after each trip command. Additionally, the pickup sample from the conductor pickups is considered:

- With 1-phase pickup, the automatic reclosing cycles set for 1-phase dead times are activated. 1-phase pickup includes both pickup samples phase-to-ground and only grounding.
- With 2-phase pickup, the automatic reclosing cycles set for 2-phase dead times are activated.
- With 3-phase pickup, the automatic reclosing cycles set for 3-phase dead times are activated.

With each automatic reclosing cycle, it is checked to see if it is a 1-phase, 2-phase or 3-phase pickup. If more than one automatic reclosing cycle is configured, the sequence of the expiring automatic reclosing cycles is identical with the cycle number (1, 2, 3, etc.).

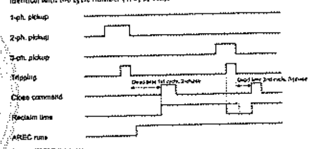

Figure 6-276 Operating-Mode Signal Examples: With Pickup/Without Action Time

6.43.4.2 Structure of the Cyclic Automatic Reclosing Function

In Figure 6-277, the functional structure of the cyclic automatic reclosing function is illustrated as a block diagram. The figure displays the important signals, coming from outside of the cyclic automatic reclosing function, and the most important signals between the individual function blocks.

The automatic reclosing function works as a state machine. From the idle state AREC ready, the automatic reclosing function goes through the tripping or pickup indications of the protection functions to the Dead time state. After expiration of the dead time, the subsequent state is reached with the closing indication. The reclaim time is also started together with the closing indication. If the reclaim time can expire without further operate or pickup indications, the automatic reclosing is successful and the automatic reclosing function turns back to idle state.

If the automatic reclosing function is restarted during the current reclaim time, there will be either a dynamic blocking or other reclosing cycles will be executed. If other reclosing cycles are possible, there will be a dead time start and the described process starts again.

After the end of a dynamic blocking, the automatic reclosing function switches back to idle state or it goes into the state Static Blocking if the blocking condition is permanently present. In the following sections, the individual function blocks are described in detail.

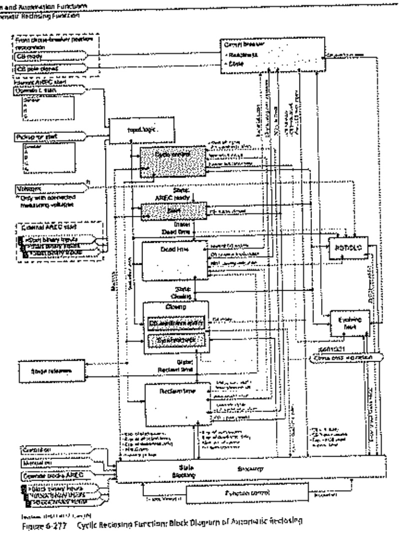

Figure 6-277 Cyclic Reclosing Function: Block Diagram of Automatic Reclosing

6.43.4.3 Input Logic for Operating Modes with Tripping

The operate indications are used as starting signals. For operating modes with action time, the start of the action time(s) occurs with the pickup messages. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

Applications with 3-Pole Tripping

For applications with only 3-pole tripping options, the internal operate indications are always 3-pole. For external starts, there is a binary input, which signalizes a 3-pole tripping of the external protection device. The outputs of the input logic signalize that the reclosing start has occurred through a 3-pole operate indication.

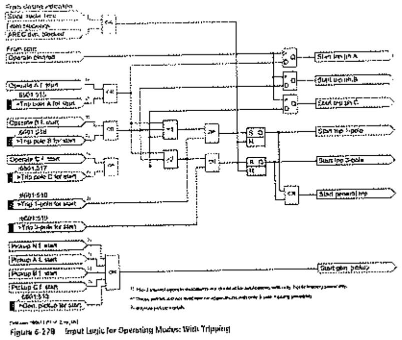

Figure 6-278 Input Logic for Operating Modes: With Tripping

6.43.4.4 Input Logic for Operating Modes with Pickup

The operate indications and the pickup indications are used as starting signals. The internal pickup indications are processed selective to the phase. Through binary inputs, the pickup information can also be coupled by external protection devices (>Pickup A for start, >Pickup B for start and >Pickup C for start). Optionally, the pickup information can be externally captured as a pickup sample, thus, as a 1-phase, 2-phase and 3-phase pickup.

The outputs of the input logic signalize if the automatic reclosing start occurs through a 1-phase, 2-phase, or 3-phase pickup:

- On Start with 3-phase pickup, it is recognized if all 3 phases were picked up in the period from the first raising pickup indication up to the last clearing outgoing pickup indication.
- On Start with 2-phase pickup, it is recognized if all 2 phases were picked up in the period from the first raising pickup indication up to the last clearing pickup indication and at no time 3 phases.
- On Start with 1-phase pickup, it is recognized if only 1 phase was picked up in the period from the first raising pickup indication up to the last clearing pickup indication.

For operating modes with action time, the start of the action time(s) occurs with the pickup indications. During operating modes with pickup, the pickup indications affect the selection of the dead times. During all operating modes, the pickup indications are also required during the processing of faults and for supervision during the reclaim time.

The automatic reclosing operating modes with pickup are only ideal for applications with 3-pole tripping. Therefore, the outputs of the input logic always signal 3-pole operate indications.

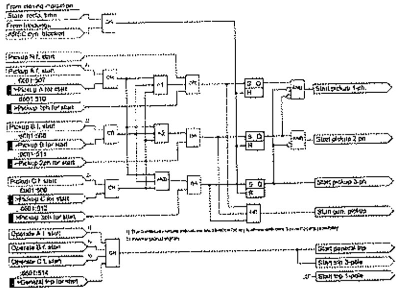

Figure 6-279 Input Logic for Operating Modes: With Pickup

6.43.4.5 Start

In the Start function block, the automatic reclosing function is switched from the idle state AREC ready to the state Dead time, see Figure 6-280. The length of the starting signals is controlled with a supervision time.

Start-Signal Supervision Time

The start-signal supervision stops the automatic reclosing if the short circuit is not switched off within the normal time; for example, in the case of a circuit-breaker failure.

With the first raising operate indication, the start-signal supervision time is initiated, parameter Start signal supervis. time. The time is stopped as soon as no operate indications are active or if the circuit breaker is recognized as being no longer 3-pole closed.

The automatic reclosing function is blocked if there is an expiration of the start signal supervision time through a long operate indication. The blocking lasts until the operate indication stops, extended by a further 0.5 s.

Transition to the Dead-Time State

The transition of the automatic reclosing function to the dead-time state occurs for:

- Clearing operate indications if none of the signal inputs for operate indications are active
- or if the circuit breaker can no longer be recognized as 3-pole
- and the start-signal supervision time is not expired

Additionally, the following conditions must be fulfilled:

- The circuit breaker signalizes the readiness for automatic reclosing typically through a binary input. If the circuit breaker is not ready, the automatic reclosing function can be statically blocked. In this situation, the automatic closing function is not in idle state automatic closing function ready. The control of the circuit-breaker readiness is optional and can be turned off through settings, see also chapter 6.43.4.16 Circuit-Breaker Readiness and 6.43.4.17 Blockings.
- The circuit breaker must be closed before the 3-pole trip command. This condition is not considered if the circuit breaker auxiliary contacts are not connected to the protection device.

You can delay the transition to the dead time state through the binary input >Dead time start delay. As long the corresponding binary signal is present, the dead time of the automatic reclosing function will not be started. The maximum duration of this binary signal is monitored through a time stage that can be set, parameter Max. dead-time delay. Upon expiration of this time stage, that is, if the binary signal is present longer than permitted, the automatic reclosing function will be blocked until the end of the binary signal, additionally extended by another 0.5 s. See also chapter 6.43.4.17 Blockings.

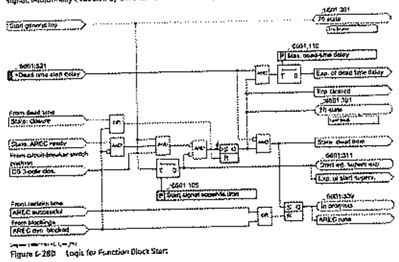

Figure 6-280 Logic for Function Block Start

6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In Figure 6-281, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter Dead time aft. 3-pole trip to invalid avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing function if the Dead time

aft. 1-pole trip [illegible] is set to invalid. If both dead times are set to invalid, the respective automatic reclosing cycle will be completely blocked. With the binary input >Block 79 cycle, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (AR only after 1p. trip). The approval or switch over of special protection stages only occurs for types of faults that lead to 1-pole tripping.

Action Time

If the automatic reclosing function is in the idle state automatic reclosing function ready, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter Start from idle state allow. and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.

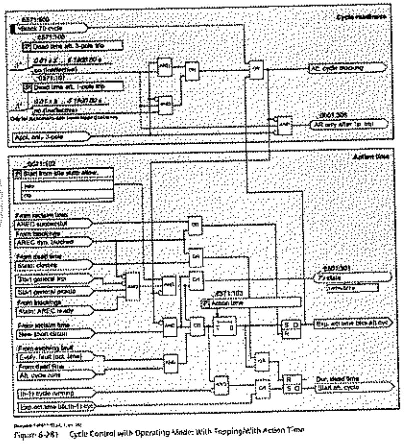

Figure 6-281 Cycle Control with Operating Mode: With Tripping/With Action Time

6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time

The cycle control checks the readiness for each automatic reclosing cycle and controls the process of the action time(s). In Figure 6-282, the cycle control is illustrated.

Cycle Availability

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter Dead time aft.1ph. pickup to invalid avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to Dead time aft.2ph. pickup and Dead time aft.3ph. pickup. If all 3 dead times are set to invalid, the respective reclosing cycle will be completely blocked. With the binary input >Block 79 cycle, you can block the associated automatic reclosing cycle.

Action Time

If the automatic reclosing function is in the idle state automatic reclosing function ready, an incoming general pickup will affect the start of the action time. This applies for the reclosing function cycles that are released through the parameter Start from idle state allow. and not blocked.

During one of the started action times, the corresponding reclosing cycle is blocked and the reclosing cycle is assigned the next highest cycle number, whose action time is running and is not blocked.

With raising trip commands, the action times are stopped and reset. The process state of the action times existing at this moment determines the automatic reclosing cycle that should be started.

If all initiated action times expire without capturing a tripping, the automatic reclosing function does not take place. However, if a tripping function is initiated after expiry of the action time, the automatic closing function is blocked for 3 seconds. A new start of the reclosing function is only possible if the general pickup is no longer active.

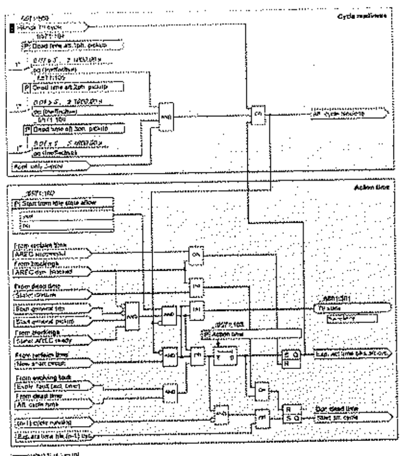

Figure 6-282 Cycle Control with Operating Mode: With Pickup/With Action Time

6.43.4.8 Cycle Control with Operating Mode 3: With Tripping/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In Figure 6-283, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number n and apply for all other configured automatic reclosing cycles.

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter `Dead time aft. 3-pole trip` to `invalid` avoids an automatic reclosing after 3-pole tripping. Correspondingly, there is no automatic reclosing function after 1-pole tripping if the `Dead time aft. 1-pole trip` [17] is `invalid`. If both dead times are set to `invalid`, the respec- [illegible]

[17] is not available for devices with only 3-pole tripping

[illegible] automatic reclosing cycle can be completely blocked. With the binary input `>Block 79 cycle`, you can block the associated automatic reclosing cycle.

For applications with 1-pole tripping, the cycle control provides a signal, based on which the protection functions can recognize that the automatic reclosing function only occurs after 1-pole tripping (`AR only after 1p. trip`). The approach to switch over of special protection stages only occurs for types of faults that lead to 1-pole tripping.

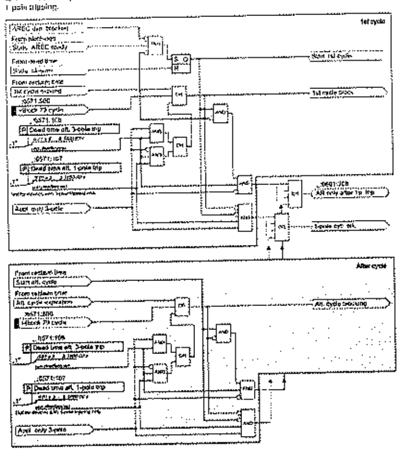

Figure 6-283 Cycle Control with Operating Mode: With Tripping/Without Action Time

6.43.4.9 Cycle Control with Operating Mode 4: With Pickup/Without Action Time

The cycle control checks the availability for each automatic reclosing cycle. In Figure 6-284, the cycle control for the 1st automatic reclosing cycle and other reclosing cycles is illustrated. The further automatic reclosing cycles are generally described with the cycle number n and apply for all other configured automatic reclosing cycles.

The cycle availability is influenced through the parameterization of the dead time and through a binary input. In this way, setting the parameter `Dead time aft. 1ph. pickup` to `invalid` avoids an automatic reclosing after 3-pole tripping due to 1-phase short circuits. This also applies to `Dead time aft. 2ph. pickup` and `Dead time aft. 3ph. pickup`. If all 3 dead times are set to `invalid`, the respective reclosing cycle will be completely blocked. With the binary input `>Block 79 cycle`, you can block the associated automatic reclosing cycle.

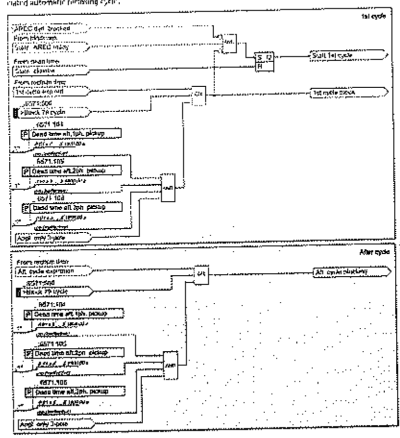

Figure 6-284 Cycle Control with Operating Mode: With Pickup/Without Action Time

6.43.4.10 Stage Release

The function block Stage release creates output indications for the release or switching over of special stages for protection functions (stage release in the 1st cycle or stage release in the n. cycle). Examples for this are the release of overreaching zones with distance protection and the dynamic adjustment of delays or threshold values with overcurrent protection.

Figure 6-285 shows the tripping stage release for the 1st automatic reclosing cycle. With available automatic reclosing functions, the tripping stage release typically occurs up to the expiration of the dead time. The cycle number in this state is on 1. However, if the automatic reclosing cycle is set only for 1-phase [18], the tripping stage release will be reset to the beginning of the 1-phase dead time. This is necessary, since every additional evolving fault that occurs within the dead time causes a 3-pole cut-off, and subsequently, the automatic reclosing function can no longer take place.

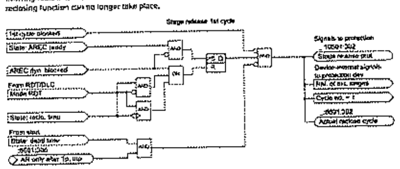

Figure 6-285 Stage Release for Protection Functions in the 1st Automatic Reclosing Cycle

The tripping stage release for higher automatic reclosing cycles is set to the beginning of the reclaim time for rising edge close commands. Simultaneously, the cycle number is increased. The reset condition is identical to the condition for the 1st automatic reclosing cycle. If the reduced dead time (RDT) mode is selected and no additional reduced dead time occurs, the release of the 2nd cycle will be maintained, since it can be assumed that the opposite end is open.

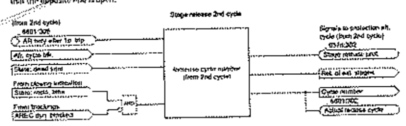

Figure 6-286 Stage Release for Protection Functions Starting With the 2nd Automatic Reclosing Cycle

6.43.4.11 Dead Time for Operating Modes With Tripping

In the Dead time function block, that dead time which corresponds with the previous trip command is started. After expiration of the dead time, the automatic reclosing function changes to the status Switch on. Figure 6-287 shows the dead time logic.

There are the following time stages that can be set differently:

- Dead time after 3 pole tripping
- Dead time after evolving fault

Setting the parameter `Dead time aft. 3-pole trip` to = (= invalid) avoids an automatic reclosing after 3-pole tripping.

[18] [illegible] for devices with only 3-phase tripping

As soon as an evolving fault is recognized (see chapter 6.43.4.13 Evolving-Fault Detection During Dead Time), switching to an automatic reclosing cycle for 3 pole interruption occurs. With the 3-pole cut-off of the evolving fault, a separate adjustable dead time for the evolving fault begins. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the first disruption plus the dead time for the evolving fault. With the setting of the parameter `Dead time aft. evolv. fault` to = (= invalid), no other automatic reclosing cycle is executed after tripping by the evolving fault. The tripping through evolving faults is then finished.

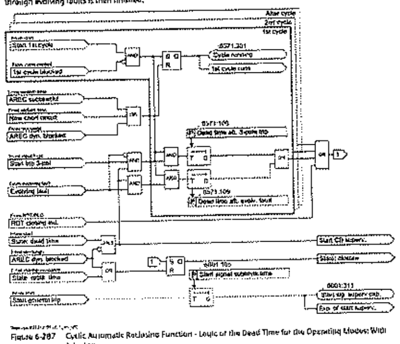

Figure 6-287 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes: With Tripping

6.43.4.12 Dead Time for Operating Modes with Pickup

In the dead time function block, the dead time corresponding to the type of short circuit that led to the trip command is started. The automatic reclosing operating modes with pickup are only ideal for applications with 3-pole tripping. After expiration of the dead time, the automatic reclosing function changes to the status Switch on. Figure 6-288 shows the dead time logic.

There are 4 time stages that can be set differently:

- Dead time after 1-phase short circuits
- Dead time after 2-phase short circuits
- Dead time after 3-phase short circuits
- Dead time for evolving faults

In this way, setting the parameter `Dead time aft.1ph. pickup` to `invalid` avoids an automatic reclosing after 3-pole tripping due to 1 phase short circuits. This also applies to `Dead time aft.2ph. pickup` and `Dead time aft.3ph. pickup`.

As soon as an evolving fault is recognized (see chapter 6.43.4.13 Evolving-Fault Detection During Dead Time), a separate dead time for faults begins with the stopping of the fault. The total dead time is composed of the part of the dead time that expired until the evolving fault was stopped for the 1st disruption plus the dead time for the evolving fault. With the setting of the `Dead time aft. evolv. fault` to `invalid`, no other automatic reclosing cycle is executed after tripping through the evolving fault. The tripping through evolving faults is then finished.

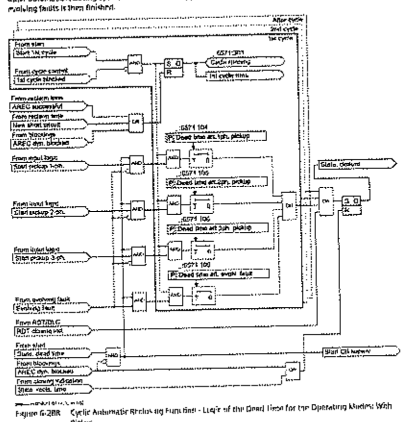

Figure 6-288 Cyclic Automatic Reclosing Function - Logic of the Dead Time for the Operating Modes: With Pickup

6.43.4.13 Evolving-Fault Detection During Dead Time

Evolving faults are short circuits, which occur after switching off a short circuit during dead time. This may be the case during 1-pole tripping and there is a short circuit in the non-switched conductors after this.

After 3-pole tripping there may also be evolving faults if the line is fed through a second (non-3-pole) opened circuit breaker, for example, for systems with a 1 1/2 circuit breaker layout.

The evolving-fault detection is divided into components.

- Detection of Evolving Faults
- Evolving-Faults Processing
- 3-pole circuit-breaker intertripping during evolving faults

The procedure during evolving faults is illustrated in Figure 6-289.

Detection of Evolving Faults

For the detection of an evolving fault, the following criteria can be selected through parameters:

- Parameter Evolving-fault detection = with trip
  For this setting, any tripping during the dead time leads to evolving-fault detection. At any tripping it is decided if an internal protection function is tripped or if the tripping is signaled through a binary input. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not.
- Parameter Evolving-fault detection = with pickup
  Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is recognized through a binary input.
- Binary input >Evolving fault start
  The evolving-fault detection can also be introduced through a binary input without an internal protection pickup being available.

Reaction to Evolving Faults

After a recognized evolving fault, the automatic reclosing function can be influenced in 2 ways.

- Parameter Response to evolv. faults = blocks 79
  As soon as an evolving fault is recognized, the reclosing function will be blocked. There are no other reclosing attempts and the automatic reclosing function is blocked until the pickup and operate indications causing the evolving fault disappear.
- Parameter Response to evolv. faults = strt. evol.flt.dead time
  As soon as an evolving fault is recognized, an automatic reclosing cycle for 3-pole interruption is switched to, the automatic reclosing function does not allow any 1-pole tripping until the fault is solved or there is a final switch off; thus, every following trip command will be 3-pole. When the evolving fault is fixed, the separate dead time for faults will start, see also chapter **Dead time**. The further process is as by 3-pole cycles.

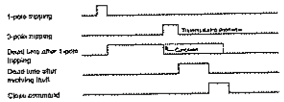

Figure 6-289 Cyclic Automatic Reclosing Function - Example for an Evolving Fault

For tripping through evolving faults, the entire dead time consists of the part of the dead time expired until disconnecting the evolving fault for the 1-pole interruption plus the dead time for the fault together, see Figure 6-290.

The dead time for evolving faults is started with the return of the operate indication or with the opening of all 3 circuit-breaker poles, provided the circuit-breaker auxiliary contacts are connected.

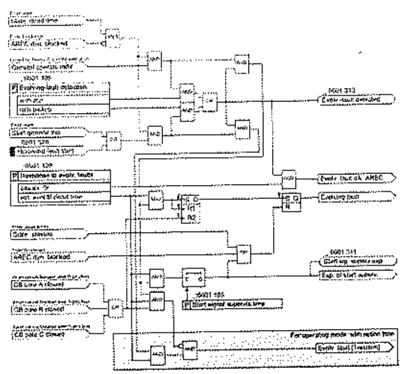

Figure 6-290 Cyclic Automatic Reclosing Function - Logic of Evolving-Fault Detection

6.43.4.14 Closing Indication and Close Command

After the expiration of the dead time, the automatic reclosing function will be in the closing state.

The closing state can depend on the following influences, see Figure 6-291:

- through a synchrocheck if the circuit breaker was opened during the 3-pole dead time
- Through the readiness of the circuit breaker signaled through the binary input
- Through a binary input for delaying the close command (>Delay close cmd.)

The Close cmd. indication is a requirement for the assignment of the actual close command to the circuit breaker.

The mentioned criteria must not be fulfilled directly after expiration of the dead time. If a dead-time prolongation is set, the mentioned criteria will be checked during the prolongation. With the release of the closing indication, the automatic reclosing function will switch to the reclaim time state.

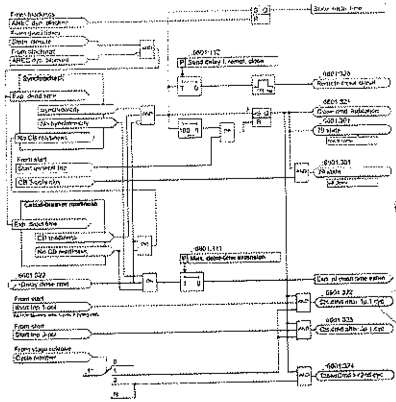

Figure 6-291 Cyclic Reclosing Function: Logic for the Closing Indication

Testing the Circuit-Breaker Readiness Directly before Closing

For each of the automatic reclosing cycles, you can set if a test of the circuit-breaker readiness should occur directly before closing (parameter CB ready check bef. close, Figure 6-292). Independent of this, a test of the circuit-breaker readiness before the start of the 1st automatic reclosing cycle can be set, see Chapter 6.43.4.5 Start and chapter 6.43.4.16 Circuit-Breaker Readiness .

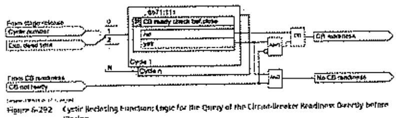

Figure 6-292 Cyclic Reclosing Function: Logic for the Query of the Circuit-Breaker Readiness Directly before Closing

Synchrocheck

For each of the configured automatic reclosing cycles, you can set if a synchrocheck should be executed and which functionality should be used here, see Figure 6-293. You may only use the internal synchrocheck if the device is connected to a voltage transformer.

Alternatively, you can also connect an external device with synchrocheck through a binary input.

The measuring request for the synchrocheck is placed if the optional test of the circuit-breaker readiness was positive. The measuring request for the synchrocheck exists until the synchrocheck assigns the allowance for the closure. If the allowance is not given within the set maximum dead time extension, the closure will be cancelled through the blocking of the automatic reclosing function. The minimum duration of the measuring request is 50 ms.

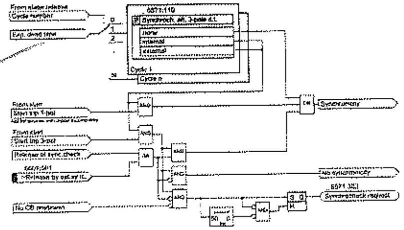

Figure 6-293 Cyclic Reclosing Function: Logic for the Inquiry of the Synchronism

Close Command

As soon as the test of the circuit breaker readiness and the synchrocheck deliver a positive result, the closing indication will be created. It will be assigned for 100 ms. The actual close command is not created by the automatic reclosing function, but rather from the circuit-breaker function block outside of the automatic reclosing function. Here the set maximum duration of the close command is also considered.

In addition to the closing indication, additional indications will be created that describe the type of closure. These include:

- Close command after 3-pole tripping in the first cycle (Cls.cmd after 3p.1.cyc)
- Close command after 1-pole or 3-pole tripping starting with the second cycle (CloseCmd >=2nd.cyc)

Creation of the Signal Remote close signal

The cyclic automatic reclosing function can create information Remote close signal. This information can be transferred to the protection device as a binary signal on the line that is to be protected on the opposite end. From the reclosing function, it can be processed in the operating mode adaptive dead time (ADT). Furthermore, the binary signal may be arranged as data for transmission via an existing protection interface.

The information Remote close signal is created by the closing logic. It can be delayed by a set time over the local close indication. With this delay, you can make sure that information is only set if the automatic reclosing was successful and there was no further tripping. The pulse duration of the inter-close signal has a fixed length of 500 ms.

6.43.4.15 Reclaim Time

With the assignment of the close command, the automatic reclosing function goes into the reclaim time state. During this time, it is decided if the current reclosing cycle was successful or not

- If during the reclaim time no further tripping occurs, the currently running automatic reclosing cycle, and thus the entire automatic reclosing, was successful.
- If during the reclaim time another tripping occurred, the currently running automatic reclosing cycle was not successful. If other automatic reclosing cycles are permitted, one of these cycles will be used to continue the process. If, in contrast, the currently executed cycle was the last permissible cycle, the automatic reclosing process will end and be reported as unsuccessful.

In both cases, the automatic reclosing function switches back to the idle state automatic reclosing function ready.

Short Circuits during Running Reclaim Time

A trip command that occurs during a reclaim time leads to a cancellation of the reclaim time. If further automatic reclosing cycles are allowed, the regulation of the cycle depends on if the automatic reclosing function is executed in an operating mode with action times or without action times, see Figure 6-294.

- With operating modes with action time, the action times of all higher cycles are started with the beginning of the new general pickup if these are not blocked. The cycle with the lowest cycle number is selected, whose action time is not yet expired with the incoming trip indication. If no further cycles are possible or if the action times of all possible cycles are expired before the operate indication, there will be no further reclosing.
- With the operating modes without action time, the cycle following the current cycle will always be selected in the set cycle. If this is blocked, the cycle following this one will be selected, etc. If no higher cycles exist or if they are all blocked, there will be no further automatic reclosing.

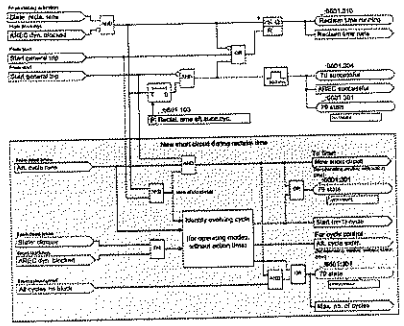

Figure 6-294 Cyclic Reclosing Function: Logic for the reclaim time

6.43.4.16 Circuit-Breaker Readiness

The automatic reclosing function requires the readiness of the circuit breaker for the following purposes, see Figure 6-295:

- Recognition of the circuit breaker readiness from the beginning:
  In idle state of the automatic reclosing function, an unavailable circuit breaker leads to the blocking of the automatic reclosing function. This monitoring is optional and must be switched off through setting if the readiness signal is not available for the protection device.
- Analysis of the circuit-breaker readiness directly before the close command:
  For each of the configured automatic reclosing cycles, it can be set whether the circuit-breaker readiness is a requirement for the assignment of the close command. This monitoring is also optional.

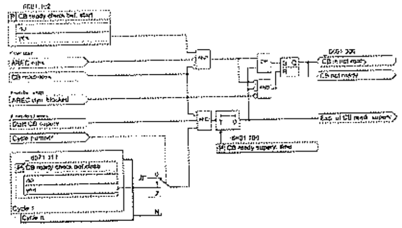

Figure 6-295 Cyclic Reclosing Function: Logic for the Circuit Breaker Readiness

6.43.4.17 Blockings

The Automatic reclosing function differentiates between 2 types of blockings, see Figure 6-296:

- Static blocking
- Dynamic blocking

Static Blocking

The Automatic reclosing function is statically blocked if the function is switched on, but is not ready for reclosing and also cannot be started as long as this blocking is present. The dynamic blocking is signaled with the indication Inactive.

The following conditions lead to the static blocking:

Condition	Indication
Manual closing of the circuit breaker, recognition through binary input or internal device control. The blocking is temporary, the duration can be set with the parameter Block. time aft. man.close.	Inactive
Circuit breaker not available for automatic reclosing function, recognition through binary input. This cause can be switched on or off through the parameter CB ready check bef.close.	Inactive
Circuit breaker of non-closed 3-pole, recognition through binary input. This criteria is used if the circuit-breaker auxiliary contacts are connected.	Inactive

Condition	Indication
No reclosing cycle possible Recognition due to the following causes: • Automatic reclosing cycle is not set. • Automatic reclosing cycles are set, but all are blocked, for example, via binary input. • There is no internal device function and no binary input configured for starting the automatic reclosing function. • With operating modes with tripping: – both 1-pole and 3-pole cycles are blocked via binary inputs. • With operating modes with pickup: – 1-phase, 2-phase and 3-phase automatic reclosing cycles, the blocking is done through binary inputs. • With operating modes without action time: – the first automatic reclosing cycle is blocked via binary input. • With the dead-line check functionality: – if the voltage measurement is not available or is disrupted.	Inactive

Dynamic Blocking

The automatic reclosing function is blocked dynamically if a blocking condition occurs while an automatic reclosing function is running. The dynamic blocking is signalized with the indication Not ready.

After the occurrence of a dynamic blocking, it is checked in intervals of 0.5 s to see if the blocking can be removed. If the blocking condition remains or if a different blocking condition occurs in the meantime, the blocking will remain. If, in contrast, the cause of the blocking disappears, the dynamic blocking will be removed if no general pickup or no tripping configured for the automatic reclosing function start is available.

A separate indication for logging exists for each individual blocking cause.

The following conditions lead to the dynamic blocking:

Condition	Indication
If no reclosing cycle fitting the fault type is released: • With operating modes with tripping: If a 1-pole or 3-pole operate indication occurs during the automatic reclosing function start input, however, the automatic reclosing function does not start in accordance with the parameterization for this type of tripping, the respective dead time will be set to invalid. • With operating modes with pickup: If a 1-phase, 2-phase or 3-phase pickup indication occurs during the automatic reclosing function starting process, but the automatic reclosing function may not be started in accordance with the parameterization for this type of pickup.	Not ready Block. by no cycle
If a protection function causes the automatic reclosing function to be blocked in accordance with the configuration	Not ready Block. by protection
If the maximum set waiting time for the delay of the start of the dead time through the binary input >Dead time start delay expires without the binary input becoming inactive during this time lapse	Not ready Blk.by max. d.t. delay
If the synchrocheck is set and the synchronism conditions after the expiration of the maximum dead-time prolongation are not fulfilled before the assignment of the close command	Not ready Blk.by max.d.t. expiry

Condition	Indication
If the inquiry of the circuit-breaker readiness is switched on directly before the close command through the parameter and the maximum dead-time prolongation expires	Not ready Blk.by CB ready sup. Blk.by max.d.t. expiry
If the closing indication is delayed through the binary input >Delay close cmd. for so long until the maximum dead time extension is exceeded before the assignment of the close command	Not ready Blk.by max.d.t. expiry
If an evolving fault occurs and the parameter Response to evolv. faults is set to Blocks 79	Not ready Blk. by evolving fault
If the start-signal supervision time for the operate indication starting from the automatic reclosing function or the starting binary input expires. In this case, a circuit breaker failure is assumed.	Not ready Blk.by strtsig.superv.
If after the start of the automatic reclosing function a dead time is already running and a blocking binary input is active, with the following binary inputs: >Blk. 1-pole AR, >Blk. 3-pole AR, >Blk. with 1-ph pickup, >Blk. with 2-ph pickup, >Blk. with 3-ph pickup	Not ready Block. by binary input
If the maximum number of automatic reclosing attempts is reached and there is a trip command within the reclaim time	Not ready Block. by max. cycles
With operating modes with action time: If the action times of all released automatic reclosing cycles expire without a trip command	Not ready Blk.by action time exp
For applications with voltage measurement and switched on functionalities with dead-line check: If during the dead time the required voltage criteria is not fulfilled	Not ready Blk.by dead-line check
For applications with voltage measurement and switched on functionalities with dead-line check: If during a running automatic reclosing cycle a failure of the measuring voltage is determined. After the completion of the automatic reclosing cycle, the dynamic blocking becomes static blocking if there is a continued failure of the measuring voltage.	Not ready Blk.by loss of voltage

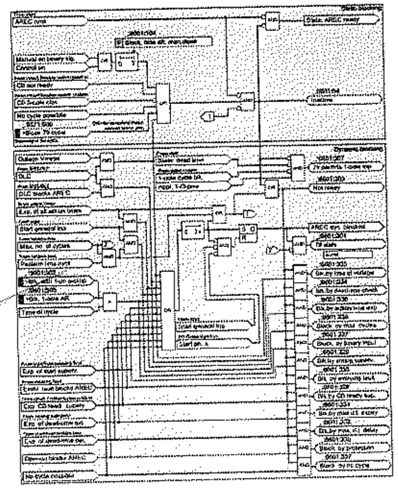

Figure 6-296 Cyclic Reclosing Function: Blocking Logic in the Example for a 1-Pole Cycle (Static and Dynamic Blocking)

6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)

The additional functions Dead-line check (DLC) and Reduced dead time (RDT), are only possible for applications with a voltage-transformer connection. Another requirement is that the voltage of the line being switched on can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line side - seen from the circuit breaker.

Both additional functions DLC and RDT are mutually exclusive, because the DLC checks if the value falls below a voltage threshold, while the RDT checks if the value exceeds the voltage threshold.

The respectively selected additional function runs in the automatic reclosing state dead time.

Reduced Dead Time (RDT)

With the Reduced dead time, a close command can be assigned before the expiration of the set dead times if the line to switch on is recognized as fault-free through the measurement of the line voltage.

The voltage measurement occurs with the 3 phase-to-phase voltages.

In systems with a grounded neutral point, the 3 phase-to-ground voltages are additionally observed.

In systems with compensated or with isolated neutral points, the largest 2 of the 3 phase-to-ground voltages are additionally considered. Through this, a RDT can also be executed with 1-phase ground connections.

For the approval of the close command with RDT, the following conditions apply:

- The automatic reclosing function is in the state dead time.
- Each measured voltage is above the set threshold values Volt. thres.f. live line/bus
  The phase-to-phase voltages are divided by √3 prior to comparing the threshold value. Thus, the phase-to-ground voltage $U_N/\sqrt{3}$ applies as the reference size for the parameterization.
- Exceeding the threshold is fulfilled for the set duration Voltage supervision time.

Dead-Line Check (DLC)

If after switching off a short-circuit the voltage on the switched off line does not disappear, the automatic reclosing function can be avoided with the dead-line check (DLC).

The voltage measurement occurs with the 3 phase-to-ground voltages.

For the release of the close command with DLC, the following conditions apply:

- The automatic reclosing function is in the state dead time.
- All measured voltages for the set duration Voltage supervision time are below the set threshold Volt. thres.f. live line/bus.
- The set dead time is expired.

As soon as the voltages fall below the threshold value for the set duration, the allowance for automatic reclosing with DLC is assigned. This also applies if the values are not below the voltage threshold until the expiration of the set dead time. In this way, an automatic reclosing is executed if the automatic reclosing function is first switched in at the end of the protected line and thus, the line is exposed to voltage again.

The automatic reclosing function is blocked by the DLC under the following conditions:

- The automatic reclosing function is in the Closure state, the dead time has expired
- All measured voltages were not simultaneously below the set threshold values Volt. thres. f. dead line/bus for the set duration Voltage supervision time during the dead time.

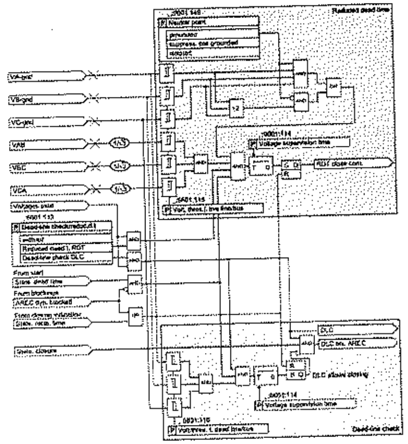

Figure 6-297 Cyclic Reclosing Function: Logic for the Functions of Reduced Dead Time and Dead-Line Check

6.43.4.19 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time

485

Addr.	Parameter	C	Setting Options	Default Setting
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal superv.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:108	General:Evolving fault detection		• with trip • with pickup	with trip
_:6601:109	General:Response to evolv. faults		• strt. evol.flt.dead time • blocks 79	blocks 79
_:6601:110	General:Max. dead-time delay		0.01 s to 300.00 s	0.50 s
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:112	General:Send delay f. remot. close		0.00 s to 300.00 s; ∞	∞
DLC / RDT				
_:6601:113	General:Dead-line check/ reduc.d.t.		• without • Reduced dead t. RDT • Dead-line check DLC	without
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
_:6601:116	General:Volt.thres. f. dead line/bus		0.300 V to 340.000 V	30.000 V
Cycle 1				
_:6571:110	Cycle 1:Start from idle state allow.		• no • yes	yes
_:6571:103	Cycle 1:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6571:108	Cycle 1:Dead time aft. 3-pole trip		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:107	Cycle 1:Dead time aft. 1-pole trip		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:104	Cycle 1:Dead time aft. 1ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:105	Cycle 1:Dead time aft. 2ph. pickup		0.00 s to 1800.00 s; ∞	1.20 s
_:6571:106	Cycle 1:Dead time aft. 3ph. pickup		0.00 s to 1800.00 s; ∞	0.50 s
_:6571:109	Cycle 1:Dead time aft. evolv. fault		0.01 s to 1800.00 s	1.20 s
_:6571:111	Cycle 1:CB ready check bef.close		• no • yes	no

Addr.	Parameter	C	Setting Options	Default Setting
_:6571:110	Cycle 1:Synchrocn. aft. 3-pole d.t.		• none • internal • external	none
_:6571:112	Cycle 1:Intern. synchro-check with		Setting options depend on configuration	

6.43.4.20 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:520	General:>Evolving fault start	SPS	I
_:6601:521	General:>Dead time start delay	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O

No.	Information	Data Class (Type)	Type
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:313	General:Evolv. fault detected	SPS	O
_:6601:314	General:ADT CloseCmd indicat.	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:320	General:Dead t. aft.evol. flt.	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:324	General:CloseCmd >=2nd.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:326	General:Remote close signal	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O
_:6601:330	General:Blk.by action time exp	SPS	O
_:6601:331	General:Blk.by max.d.t. expiry	SPS	O
_:6601:332	General:Blk.by max. d.t. delay	SPS	O
_:6601:333	General:Blk. by evolving fault	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:334	General:Blk.by dead-line check	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cyc1 1p AR	INS	O
_:6601:340	General:Cyc1 3p AR	INS	O
_:6601:341	General:Cyc2+ 1p AR	INS	O
_:6601:342	General:Cyc2+ 3p AR	INS	O
Cycle 1			
_:6571:51	Cycle 1:Mode (controllable)	ENC	C
_:6571:500	Cycle 1:>Block 79 cycle	SPS	I
_:6571:52	Cycle 1:Behavior	ENS	O
_:6571:53	Cycle 1:Health	ENS	O
_:6571:301	Cycle 1:Cycle running	SPS	O
_:6571:302	Cycle 1:Stage release prot.	SPS	O
_:6571:303	Cycle 1:Synchrocheck request	SPS	O

6.43.5 Automatic Reclosing Function with Adaptive Dead Time (ADT)

6.43.5.1 Description

Considering the cyclic automatic reclosing function, it is assumed that defined and similar dead times were set at both line ends and, if applicable, they are set for different types of faults and/or disruption cycles.

It is also possible to set the dead times only at one line end and to configure the adaptive dead time at the other end or ends. The requirements for this is that the voltage transformer aligned on the line side or a possibility to transfer a close command to a remote line end exists.

Figure 6-298 shows an example with a voltage measurement. It is assumed that device I works with defined dead times, while the adaptive dead time is configured in device II. It is important that the line is at least fed from the busbar A, so from the side with the defined dead times.

With the adaptive dead time, the automatic reclosing function at the line end II decides independently if and when a reclosing is reasonable and permissible and when it is not. The criteria is the voltage of the line at the end II, which is switched through after reclosing from end I. The reclosing at end II occurs, as soon as it exists, so that the line from end I is set back under voltage. Basically, all phase-to-phase and phase-to-ground voltages are monitored.

With an implied short-circuit, the lines at the positions I, II, and III in the example are switched off. Position I is switched on again after the dead time set there. At position III the reduced dead time (RDT) can be executed with the appropriate configuration (see chapter 6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT)) if an infeed is also available on busbar B.

If the short circuit has been cleared after successful reclosing, the line A-B from the busbar A will be set under voltage through the position I. Device II recognizes this voltage and switches on to warrant adequate voltage measurement time after a short delay. The system incident is thus successfully cleared.

If the short circuit is not cleared after closure at position I, I will be switched to the fault again. At line end II, now no healthy voltage will appear. The device here recognizes this and does not close again.

With multiple reclosing, the process may repeat if the reclosing is unsuccessful until one of the reclosings is successful or a final closing occurs.

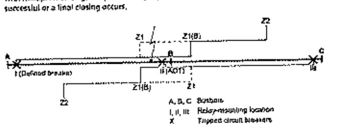

Figure 6-298 Example for Adaptive Dead Time (ADT)

As the example shows, the adaptive dead time brings along the following advantages:

- The circuit breaker at position II does not switch off again with a remaining fault and is protected through this.
- With a non-selective tripping through tripping over to position III, no more disruption cycles may exist here, because the short-circuit path through busbar B and the position II remains disrupted even with multiple reclosing.
- At position I, with multiple reclosing and even with a final tripping, an overlapping is allowed, because the line at position II remains open and thus, no actual overreaching can occur at position I.

The adaptive dead time also contains the reduced dead time (VWE), because the criteria are the same. A special setting of the reduced dead time (VWE) is unnecessary if the automatic reclosing function is used with adaptive dead time (ASP).

6.43.5.2 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:6601:1	General:Mode		• off • on • test	on
_:6601:101	General:79 operating mode		• with op., w/o act. time • with op., with act. time • w.pickup, w/o act. time • w.pickup, w. action time	with op., with act. time
_:6601:102	General:CB ready check bef. start		• no • yes	no
_:6601:103	General:Reclai. time aft.succ.cyc.		0.50 s to 300.00 s	3.00 s
_:6601:104	General:Block. time aft. man.close		0.00 s to 300.00 s	1.00 s
_:6601:105	General:Start signal superv.time		0.01 s to 300.00 s	0.13 s
_:6601:106	General:CB ready superv. time		0.01 s to 300.00 s	3.00 s
_:6601:107	General:3-pole operate by 79		• no • yes	yes
_:6601:111	General:Max. dead-time extension		0.00 s to 300.00 s; ∞	1.20 s
_:6601:114	General:Voltage supervision time		0.10 s to 30.00 s	0.10 s
_:6601:115	General:Volt. thres.f. live line/bus		0.300 V to 340.000 V	48.000 V
ADT				
_:6631:101	ADT:1-pole trip allowed		• no • yes	no
_:6631:104	ADT:Action time		0.00 s to 300.00 s; ∞	0.20 s
_:6631:105	ADT:Maximum dead time		0.50 s to 3000.00 s	5.00 s
_:6631:102	ADT:CB ready check bef.close		• no • yes	no
_:6631:103	ADT:Synchroch. aft. 3-pole d.t.		• none • internal • external	none
_:6631:106	ADT:Intern. synchrocheck with		Setting options depend on configuration	

6.43.5.3 Information List

No.	Information	Data Class (Type)	Type
General			
_:6601:51	General:Mode (controllable)	ENC	C
_:6601:87	General:>Function off	SPS	I
_:6601:524	General:>Function on	SPS	I
_:6601:347	General:Function on	SPC	C
_:6601:82	General:>Block function	SPS	I
_:6601:501	General:>Release by ext.sync.	SPS	I

No.	Information	Data Class (Type)	Type
_:6601:502	General:>Blk. with 1-ph pickup	SPS	I
_:6601:503	General:>Blk. with 2-ph pickup	SPS	I
_:6601:504	General:>Blk. with 3-ph pickup	SPS	I
_:6601:505	General:>Blk. 1-pole AR	SPS	I
_:6601:506	General:>Blk. 3-pole AR	SPS	I
_:6601:507	General:>Pickup A for start	SPS	I
_:6601:508	General:>Pickup B for start	SPS	I
_:6601:509	General:>Pickup C for start	SPS	I
_:6601:510	General:>Pickup 1ph for start	SPS	I
_:6601:511	General:>Pickup 2ph for start	SPS	I
_:6601:512	General:>Pickup 3ph for start	SPS	I
_:6601:513	General:>Gen. pickup for start	SPS	I
_:6601:514	General:>General trip for start	SPS	I
_:6601:515	General:>Trip pole A for start	SPS	I
_:6601:516	General:>Trip pole B for start	SPS	I
_:6601:517	General:>Trip pole C for start	SPS	I
_:6601:518	General:>Trip 1-pole for start	SPS	I
_:6601:519	General:>Trip 3-pole for start	SPS	I
_:6601:522	General:>Delay close cmd.	SPS	I
_:6601:52	General:Behavior	ENS	O
_:6601:53	General:Health	ENS	O
_:6601:54	General:Inactive	SPS	O
_:6601:301	General:79 state	ENS	O
_:6601:302	General:Actual reclose cycle	INS	O
_:6601:303	General:Not ready	SPS	O
_:6601:304	General:79 successful	SPS	O
_:6601:305	General:CB ready superv.expir	SPS	O
_:6601:306	General:CB is not ready	SPS	O
_:6601:307	General:79 permits 1-pole trip	SPS	O
_:6601:308	General:AR only after 1p. trip	SPS	O
_:6601:309	General:In progress	SPS	O
_:6601:310	General:Reclaim time running	SPS	O
_:6601:311	General:Start sig. superv.exp.	SPS	O
_:6601:312	General:Max. dead time expired	SPS	O
_:6601:315	General:Dead t. aft.1pole trip	SPS	O
_:6601:316	General:Dead t. aft.3pole trip	SPS	O
_:6601:317	General:Dead t. aft.1ph pickup	SPS	O
_:6601:318	General:Dead t. aft.2ph pickup	SPS	O
_:6601:319	General:Dead t. aft.3ph pickup	SPS	O
_:6601:321	General:Close cmd. indication	ACT	O
_:6601:322	General:Cls.cmd after 1p.1.cyc	SPS	O
_:6601:323	General:Cls.cmd after 3p.1.cyc	SPS	O
_:6601:325	General:3-pole operate by 79	SPS	O
_:6601:327	General:Block. by binary input	SPS	O
_:6601:328	General:Blk.by CB ready sup.	SPS	O
_:6601:329	General:Blk.by strtsig.superv.	SPS	O

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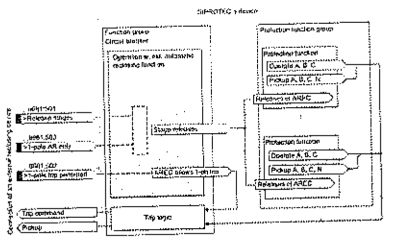
No.	Information	Data Class (Type)	Type
_:6601:330	General:Blk.by ext.cm.time exp	SPS	O
_:6601:331	General:Blk.by manual CL expiry	SPS	O
_:6601:337	General:Block. by no cycle	SPS	O
_:6601:338	General:Block. by protection	SPS	O
_:6601:335	General:Blk.by loss of voltage	SPS	O
_:6601:336	General:Block. by max. cycles	SPS	O
_:6601:339	General:Cycl. 1p AR	INS	O
_:6601:340	General:Cycl. 3p AR	INS	O
ADT			
_:6631:51	ADT:Mode (controllable)	ENC	C
_:6631:501	ADT:>Remote close signal	SPS	I
_:6631:52	ADT:Behavior	ENS	O
_:6631:53	ADT:Health	ENS	O
_:6631:301	ADT:ADT is running	SPS	O
_:6631:302	ADT:Stage release prot.	SPS	O
_:6631:303	ADT:Synchrocheck request	SPS	O

6.43.6 Cooperation with External Automatic Reclosing Function

6.43.6.1 Description

The operation of an external reclosing device with the SIPROTEC protection device occurs through the function mode Operation with external automatic reclosing function. In this function mode, the SIPROTEC protection functions create the trip command and the external reclosing device creates the close command.

The following figure shows the interaction of an external reclosing device with the functions of the SIPROTEC 5 device.



¹⁾ Only for applications with 1-pole tripping capability

Figure 6-299 Connection of an External Automatic Reclosing Function

There are no setting parameters for operation with external automatic reclosing functions. The function provides exclusively the following described binary inputs. The external reclosing device can thus have an influence on the effects of the internal protection functions.

The following connection possibilities exist:

- From the external reclosing function, the signal *>Release stages* can be coupled so that the protection functions use special stages or zones for release. An example is the release of an overreaching zone with a distance protection or the non-delayed tripping of an overcurrent protection stage in the 1st reclosing cycle.
- For applications with 1-pole tripping, the external reclosing can provide the signal *>1-pole trip permitted*, based on which the protection functions can switch off the 1-pole circuit breaker.
- For applications with reclosing functions only with 1-pole faults and stage or zone releases through the reclosing function can the signal *>1-pole AR only* be connected. The protection functions use this information to allow the stage or zone release only affect 1-pole faults.

6.43.6.2 Information List

No.	Information	Data Class (Type)	Type
Ext			
_:6661:51	Ext:Mode (controllable)		C
_:6661:501	Ext:>Release stages		I
_:6661:502	Ext:>1-pole trip permitted		I
_:6661:503	Ext:>1-pole AR only		I
_:6661:52	Ext:Behavior		O
_:6661:53	Ext:Health		O
_:6661:54	Ext:Inactive		O

6.43.7 Application and Setting Notes for General Settings

For the automatic reclosing function, there are 3 functions available in the function library. In each circuit-breaker function group, a function from the automatic reclosing function can be used.

Configure one of the 3 following function specifications:

- Cyclic Automatic reclosing function
- Automatic reclosing function with adaptive dead time (ADT)
- Operation with External Automatic Reclosing Function

Starting the Automatic Reclosing Function

The configuration of the interaction between internal protection functions and the automatic reclosing function can be set separately for each protection function. The configuration occurs in a matrix view in DIGSI. The Automatic reclosing function also has the corresponding binary inputs and binary outputs through which the external protection devices can be connected to the internal Automatic reclosing function.

Configure the starting and blocking condition for the automatic reclosing function at the position shown in Figure 6-300 in DIGSI (for example, a protection function group Line is shown here) or route the corresponding binary inputs.

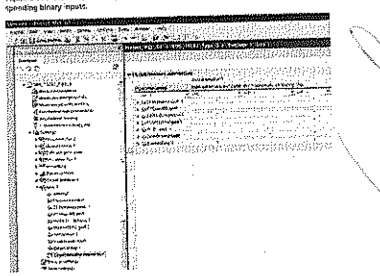


Figure 6-300 Configuration of the Protection Functions for Starting and Blocking the Automatic Reclosing Function in DIGSI

General Settings

If you use the **Cyclic automatic reclosing function** or **Automatic reclosing function with adaptive dead time function**, set the following settings under **General**.

There are no settings for the function **Operation with external automatic reclosing function**. The control occurs exclusively through binary inputs and binary outputs.

Parameter: 79 operating mode

- Default setting (_:6601:101) `79 operating mode = with op., with act. time`

You can use the `79 operating mode` parameter to determine which start criteria the automatic reclosing function works with.

Parameter Value	Description
`with op., with act. time`	The automatic reclosing function cycles are dependent on the operate time of the protection function(s). The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. Siemens generally recommends this setting for applications with 1/3-pole tripping and for applications with 3-pole tripping if a single dead time, independent of the type of connection working, is required in the automatic reclosing function cycle. Detailed information can be found in Chapter 6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function , section **Operating mode 1**
`w.pickup, w. action time`	The automatic reclosing function cycles are dependent on the operate time of the protection function(s) and the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. For applications with 3-pole tripping and dead time dependent on the circuit type, Siemens recommends this setting. Detailed information can be found in the chapter 6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function , section **Operating Mode 2**
`with op., w/o act. time`	Each operate indication starts the automatic reclosing function. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. Detailed information can be found in the chapter 6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function , section **Operating Mode 3**
`w.pickup, w/o act. time`	Each operate indication starts the automatic reclosing function. The automatic reclosing function cycles are dependent on the type of fault. The start occurs with all protection function(s) or protection stages that are configured through the automatic reclosing function start matrix. The automatic reclosing function start must be configured so that it only occurs from the protection stages/zones for which an automatic reclosing should occur after tripping. Detailed information can be found in the chapter 6.43.4.1 Operating Modes for Cyclic Automatic Reclosing Function , section **Operating Mode 4**

Parameter: CB ready check bef. start

- Default setting (_:6601:102) `CB ready check bef. start = no`

With the `CB ready check bef. start` parameter, you can determine if the readiness of the circuit breaker should be tested before starting the automatic reclosing function.

Additionally or alternatively, it is possible to check the readiness of the circuit breaker after the expiration of the dead time, directly before the assignment of the close command. There is another parameter described in the chapter 6.43.8 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function for this function.

Parameter Value	Description
`yes`	The automatic reclosing function checks the readiness of the circuit breaker for a switching cycle, consisting of a tripping-reclosing-switching. If the circuit breaker is ready - signaled through a binary input - the startup of the automatic reclosing function can occur. If the circuit breaker is not ready, the automatic reclosing function reports the static blocking. Siemens recommends using this setting. Note: The presetting of this parameter does not correspond with the recommended setting for operation. The automatic reclosing function would otherwise be blocked with a non-available circuit breaker-ready signal. Please set the parameter as recommended.
`no`	The readiness of the circuit breaker is not checked before starting the automatic reclosing function. The test also does not occur if the readiness signal from the circuit breaker is connected to a binary input on the device.

Parameter: Reclai. time aft.succ.cyc.

- Default setting (_:6601:103) `Reclai. time aft.succ.cyc. = 3.00 s`

With the `Reclai. time aft.succ.cyc.` parameter, set the time used to decide if the currently running reclosing cycle was successful or not. Detailed information about the function of the reclaim time can be found in the chapter 6.43.4.15 Reclaim Time .

The presetting for the reclaim time can be frequently maintained. In regions where thunderstorms and storms often occur, a shorter reclaim time makes sense in order to minimize the danger of the final disconnection due to sequential lightning strikes or cable spark over.

Select a long reclaim time if there is no possibility for circuit-breaker supervision with multiple automatic reclosing, for example, due to missing auxiliary contacts or lacking circuit-breaker-ready information. In this case, the reclaim time must be longer than the recovery time of the circuit breaker.

Parameter: Block. time aft. man.close

- Default setting (_:6601:104) `Block. time aft. man.close = 1.00 s`

With the `Block. time aft. man.close` parameter, the time is determined for which the automatic reclosing should be blocked after a manual connection.

Set the time so that the circuit breaker can be safely switched on and off during connection to a short circuit without the automatic reclosing function being automatically closed.

Parameter: Start signal supervis.time

- Default setting (_:6601:105) `Start signal supervis.time = 0.25 s`

With the `Start signal supervis.time` parameter, set the maximum time after which a circuit breaker must be opened after a trip command. If the time expires, a failure of the circuit breaker is assumed and the automatic reclosing function is dynamically blocked.

Detailed information about the function of the start supervision time can be found in the chapter 6.43.4.5 Start .

> **NOTE**
>
> With the use of an internal or external circuit-breaker failure protection at the same line branch, observe the following:
>
> The start supervision time should be the same as the circuit-breaker failure protection time delay. With this, you can make sure that in the case of a circuit-breaker failure followed by the tripping of the busbar, no automatic reclosing will be executed.
>
> (Note: An exception to this recommendation is described below.)

Parameter: CB ready superv. time

The setting of this parameter is only important if the cycle-specific parameter `CB ready check bef.close` is set to `yes` . Otherwise, this parameter has no effect.

- Default setting (_:6601:106) `CB ready superv. time = 3.00 s`

With the `CB ready superv. time` parameter, you can determine after which maximum time after the tripping the circuit breaker must be ready for the reclosing function.

Set the time somewhat longer than the regeneration time of the circuit breaker after an OFF-ON-OFF cycle.

Detailed information about the function can be found in Chapters 6.43.4.16 Circuit-Breaker Readiness and 6.43.4.14 Closing Indication and Close Command .

Parameter: Evolving-fault detection

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting (_:6601:108) `Evolving-fault detection = with trip`

With the `Evolving-fault detection` parameter, you can determine which criteria is used to recognize an evolving fault. The actual effect of the recognized evolving fault on the automatic reclosing function can be set with the parameter described below `Response to evolv. faults` .

Evolving faults are short circuits, which occur after switching off a short circuit during dead time.

You can find detailed information about evolving-fault detection in the chapter 6.43.4.13 Evolving-Fault Detection During Dead Time .

Parameter Value	Description
`with trip`	Evolving faults are recognized if an operate indication occurs during the dead time. Thus, it does not matter if the tripping-protection function is configured for the start of the automatic reclosing function or not. The pickup of a protection function without an operate indication does not lead to evolving fault detection.
`with pickup`	Evolving faults are detected if during the dead time a protection function configured for the automatic reclosing function start is picked up or if an external pickup is detected through a binary input.

For applications with 1/3-pole tripping, Siemens recommends the setting `with trip` if the system is adequately interconnected.

If multiple individual lines in a row form a total transmission path, the setting `with pickup` may be better suitable. With this setting, you can prevent 2 lines following each other from switching to 1-pole in different conductors during evolving faults. The consequence of this fault would be the remainder of a single conductor in the dead time for the overall transmission path. This is particularly important if power plants are coupled through the overall transmission path.

Parameter: Response to evolv. faults

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting (_:6601:109) `Response to evolv. faults = blocks 79`

With the `Response to evolv. faults` parameter, you can determine how the automatic reclosing function reacts to recognized faults.

You can find detailed information about the automatic reclosing function for faults in the chapter 6.43.4.13 Evolving-Fault Detection During Dead Time

Parameter Value	Description
blocks 79	The automatic reclosing function is immediately blocked until the dropout of the fault. For blockings through faults during the 1-pole dead times, you can force a 3-pole trip command through the automatic reclosing function if the you set the parameter 3-pole operate by 79 to yes.
strt. evol.flt.dead time	After the 3-pole trip command to clear up the fault, the automatic reclosing function starts a new 3-pole automatic reclosing function cycle with the set Dead time aft. evolv. fault .

Parameter: Max. dead-time delay

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting (_:6601:110) Max. dead-time delay = 0.5 s

With the Max. dead-time delay parameter, you determine at which time the starting of the dead time may be delayed before the automatic reclosing function is dynamically blocked.

The delay of the start of the dead time is possible with the binary input >Dead time start delay .

You can find detailed information about the functionality in the chapter 6.43.4.5 Start .

Parameter: Max. dead-time extension

- Default setting (_:6601:111) Max. dead-time extension = 1.2 s

With the Max. dead-time extension parameter, you determine the time by which the dead time may be extended before the automatic reclosing function is dynamically blocked.

With the setting oo (invalid), the extension is unlimited.

An extension of the dead time can be required under the following conditions:

- Waiting for the readiness of the circuit breaker
- Inquiry of a synchronous test
- Delay through binary input in order e.g. to give the leading automatic-reclosing function priority in a system with 1 1/2 circuit breaker layout.

Remember that longer dead times after 3-pole disconnection are only permissible if no stability problems occur or if a synchronous test occurs before the reclosing.

You can find detailed information about the functionality in the chapter 6.43.4.14 Closing Indication and Close Command .

Parameter: Voltage supervision time

This parameter is only important if you use the subfunctions RDT, DLC, or the ADT function. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting (_:6601:114) Voltage supervision time = 0.1 s

With the Voltage supervision time parameter, you can determine the measuring time that is available as a criteria for the voltage decision. It should be longer than all transient oscillations through switching operations.

For the subfunctions Reduced dead time and Reclosing function with adaptive dead time, this measuring time applies for the determination of the surpassing of a voltage threshold. For the subfunction Dead-line check, the surpassing of a voltage threshold is checked.

Siemens recommends the setting 0.10 s.

Detailed information about the functionality can be found in the following parameters and in the chapters 6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT) and 6.43.5.1 Description .

Parameter: Volt. thres.f. live line/bus

This parameter is only important if you use the subfunction RDT or the function ADT. If you do not use any of these functions, the setting of this parameter is free to select.

- Default setting (_:6601:115) Volt. thres.f. live line/bus = 48 V

With the Volt. thres.f. live line/bus parameter, you can determine the limit voltage above which the line should be seen as fault-free. It must be lower than the smallest expected operating voltage. The phase-to-ground voltage applies as the reference value.

Detailed information about the functionality can be found in the following settings and in the chapters 6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT) and 6.43.5.1 Description .

Parameter: Dead-line check/reduc.d.t

This parameter is not important and cannot be set if you use the ADT function (automatic reclosing function with adaptive dead time).

- Default setting (_:6601:113) Dead-line check/reduc.d.t = without

With the Dead-line check/reduc.d.t parameter, you can determine if the automatic reclosing function should work with one of the additional functions Dead-line check DLC or Reduced dead t. RDT

Parameter Value	Description
without	The automatic reclosing function occurs after the expiration of the parameter-ized dead times. DLC or RDT are not activated.
Reduced dead t. RDT	The automatic reclosing function works with a reduced dead time (RDT).
Dead-line check DLC	The automatic reclosing functions works with dead-line check. The closing indication is only assigned if the line was really de-energized during the dead time.

You can find detailed information about the functionality in the chapter 6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT) .

NOTE

Use RDT or DLC only if the voltages of the line can be correctly measured with an open circuit breaker. This is only possible if the voltage transformer is aligned on the line-side - seen from the circuit breaker.

Parameter: Volt.thres. f. dead line/bus

This parameter is only important if you use the Dead-line check subfunction. If you do not use any of this subfunction, the setting of this parameter is free to select.

- Default setting (_:6601:116) Volt.thres. f. dead line/bus = 30 V

With the Volt.thres. f. dead line/bus parameter, you can determine the limit voltage below which the line should be seen with certainty as idle or switched off. The threshold value is used by the Dead-line check subfunction (dead-line check). The reference size is the phase-to-ground voltage.

You can find detailed information about the functionality in the chapter 6.43.4.18 Dead-Line Checking (DLC) and Reduced Dead Time (RDT) .

Parameter: Send delay f. remot. close

With the Send delay f. remot. close parameter, you can determine after which time after the automatic reclosing function the information is sent to the remote closing.

- Default setting (_:6601:112) Send delay f. remot. close = oo (invalid)

The transmission delay prevents the device operating in the adaptive dead time mode on the opposite side from closing unnecessarily if the local reclosing function remains unsuccessful. On the other hand, it must be remembered that the line is not available for transporting energy as long as the opposite end is also closed. Thus, the Send delay f. remot. close must be added to the dead time in order to determine the system stability.

You can find detailed information about this functionality in the chapter 6.43.4.14 Closing Indication and Close Command .

6.43.8 Application and Setting Notes for 1 Cycle of the Cyclic Automatic Reclosing Function

For the function of the cyclic automatic reclosing function, 1 cycle is preset. The preset cycle cannot be deleted. You can add and delete more cycles from the function library in DIGSI 5.

Parameter: Start from idle state allow.

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode with action time.

- Default setting (_:6571:102) Start from idle state allow. = yes

With the parameter Start from idle state allow. you can determine whether the action time of this automatic reclosing cycle is started, if the automatic reclosing function is in idle state during with incoming general pickup. Please set the parameter always to yes , if the automatic reclosing function is configured for only 1 cycle. If several cycles are configured, you can control the effectiveness of the automatic reclosing cycles with this parameter and various action times

Detailed information about the functionality can be found in Chapters 6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time and 6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time .

Parameter: Action time

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode with action time.

- Default setting (_:6571:103) Action time = 0.2 s

With this parameter Action time you can determine, within which time frame the trip command must appear, in order to start the automatic reclosing function. If the trip command occurs only after the action time has expired, automatic reclosing does not occur within the active automatic reclosing cycle.

You can find detailed information about the functionality in

Chapters 6.43.4.6 Cycle Control with Operating Mode 1: With Tripping/With Action Time and 6.43.4.7 Cycle Control with Operating Mode 2: With Pickup/With Action Time .

Parameter: Dead time aft. 3-pole trip

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode with tripping.

- Default setting (_:6571:108) Dead time aft. 3-pole trip = 0.5 s

With this parameter Dead time aft. 3-pole trip , you can determine after which dead time the automatic reclosing function will be executed. After a 3-pole trip of the circuit breaker, the system stability is priority. Since the switched off line cannot develop synchronizing forces, only a short dead time is permitted in most cases. The usual duration is 0.3 s to 0.6 s. A longer period can be tolerated if a synchrocheck is carried out prior to reclosing. Longer 3-pole dead times are also possible in radial systems.

Parameter: Dead time aft.1ph. pickup, Dead time aft.2ph. pickup, Dead time aft.3ph. pickup

This parameter is only important and can be set if you use the automatic reclosing function in an operating mode with pickup.

- Default setting (_:6571:104) Dead time aft.1ph. pickup = 1.2 s
- Default setting (_:6571:105) Dead time aft.2ph. pickup = 1.2 s
- Default setting (_:6571:106) Dead time aft.3ph. pickup = 0.5 s

With the 3 dead-time parameters, you can determine after which dead time the automatic reclosing function will be executed. Please set the times as desired for the respective type of short circuit.

- The parameter Dead time aft.1ph. pickup applies to dead times after 1-phase short circuits and the following protection tripping: A, B, C, or A-Gnd, B-Gnd, C-Gnd
- The parameter Dead time aft.2ph. pickup applies to dead times after 2-phase short circuits and the following protection tripping: A-B, B-C, C-A, or A-B-gnd, B-C-gnd, C-A-gnd
- The parameter Dead time aft.3ph. pickup applies to dead times after 3-phase short circuits and the following protection tripping: A-B-C or A-B-C-Gnd

NOTE

If you would like to avoid automatic reclosing during individual short circuit types, please set the respective dead times to oo (invalid).

Example:

After 1-phase short circuits, the automatic reclosing function should occur after 1.2 s. The automatic reclosing function should not occur for 2-phase and 3-phase short circuits.

For this application, the parameters should be set as follows:

- Dead time aft.1ph. pickup = 1.2 s
- Dead time aft.2ph. pickup = oo (invalid)
- Dead time aft.3ph. pickup = oo (invalid)

Parameter: Dead time aft. evolv. fault

These parameters are only significant if the parameter (_:6601:109) Response to evolv. faults is set to strt. evol.flt.dead time .

- Default setting (_:6571:109) Dead time aft. evolv. fault = 1.2 s

With the parameter Dead time aft. evolv. fault , you can determine after which dead time the automatic reclosing function should be executed, if based on an evolving fault during the current dead time, a 3-pole trip has occurred. For this 3-pole dead time, stability concerns for the system are also important. Often, this dead time as well as the parameter (_:6571:108) Dead time aft. 3-pole trip can be set.

Detailed information about the function during evolving faults during dead time are described in Chapter 6.43.4.13 Evolving-Fault Detection During Dead Time .

Parameter: CB ready check bef.close

- Default setting (_:6571:111) CB ready check bef.close = no

With the parameter CB ready check bef.close you can determine if after the expiration of the dead time (meaning, directly prior to assigning the close command) readiness of the circuit breaker should be queried.

Parameter Value	Description
no	With the setting no , the automatic reclosing function does not check again the readiness of the circuit breaker prior to assigning the close demand. Siemens recommends this setting, if it is sufficient to check the readiness of the circuit breaker for the entire switching cycle once before the start of a reclosing function, consisting of tripping-reclosing-tripping. The setting for checking the readiness of the circuit breaker prior to the start of the automatic reclosing function is done using the parameter (_:6601:102) CB ready check bef. start .

Parameter Value	Description
yes	With the setting yes , the dead time can be extended if after the expiration of the dead time the circuit breaker is not ready for the next ON-OFF cycle. The maximum delay of the dead time can be set with the parameter (_:6601:111) Max. dead-time extension . Siemens recommends this setting, if it can be assumed that the circuit breaker becomes available to switch on the reclosing function only after an additional waiting period.

Detailed information about the function can be found in Chapters 6.43.4.16 Circuit-Breaker Readiness and 6.43.4.14 Closing Indication and Close Command .

Parameter: Synchroch. aft. 3-pole d.t.

- Default setting (_:6571:110) Synchroch. aft. 3-pole d.t. = none

With the parameter Synchroch. aft. 3-pole d.t. you can determine if a synchrocheck must be carried out for the configured automatic reclosing cycle.

If during a 3-pole interruption in the system stability problems may be a concern, the synchrocheck should be carried out. If only 1-pole reclosure cycles are possible or stability problems are not to be expected during the 3-pole dead time, for example, due to a highly intermeshed system or radial system, please select the parameter none

Parameter Value	Description
none	During the automatic reclosing cycle a synchrocheck is not executed.
internal	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. For the synchrocheck a synchrocheck stage of the internal synchronization function is used, which is contained in the same function group as the circuit breaker and the automatic reclosing function. The selection of the synchrocheck stage that is used in the automatic reclosing cycle occurs through the following described parameter Internal synchrocheck.
external	In the configured automatic reclosing cycle, a synchrocheck is executed after a 3-pole dead time prior to the close command of the circuit breaker. An external synchrocheck device initiates the synchrocheck. The external synchrocheck device is connected with the binary signals Synchrocheck request and >Release by ext.sync. . Detailed information about the function can be found in Chapter 6.43.4.14 Closing Indication and Close Command under the section Synchrocheck

Parameter: Internal Synchrocheck

These parameters are only significant if the previously described parameter (_:6571:110) Synchroch. aft. 3-pole d.t. is set to internal .

With the parameter Internal Synchrocheck, you can determine which function block of the synchronization function for the automatic reclosing function is used after a 3-pole dead time. This selection is only possible for function blocks of the synchronization function, and which are included in the same circuit-breaker function group as the automatic reclosing function. The setting options of the parameter will be generated dynamically, according to the actual parameterization.

6.44 Fault Locator

6.44.1 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.

6.44.2 Structure of the Function

The Fault locator function can be used in protection function groups with 3-phase current and voltage measurements.

Figure 6-301 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.

The fault location is calculated based on the line parameter. The fault-location calculation starts with operate indication or for dropout of the short-circuit protection.

The following functions can start the fault locator:

- Overcurrent protection, phases or ground
- Directional overcurrent protection, phases or ground
- Instantaneous high-current tripping

NOTE

The Fault locator function does not work with all possible current and voltage transformer connection types. An error message is displayed in DIGSI 5 if the Fault locator function cannot work with the set types. You will find the connection types, in this case check the current and voltage transformer connection type. You will find the current transformer connection or voltage transformer connection settings in DIGSI 5 under Power-system data → Measuring point I-3ph or Power-system data → Measuring point V-3ph.

The Fault locator function only works with the following current and voltage transformer connection types (see parameter value).

Parameter	Parameter Value
CT connection	3-phase + IN-separate
	3-phase + IN
	3-phase
VT connection	3 ph-to-gnd volt. + VN
	3 ph-to-gnd voltages

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6.44.3 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 center 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 only 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 FO line ? 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 Currents 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 at the impedance calculation result, since the current component I_{F2} 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 at 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 analyzed for the correction. You can activate and deactivate the load compensation via the Load compensation parameter.

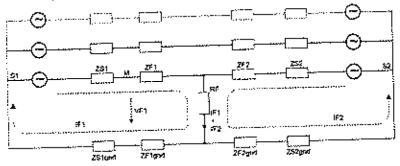

Figure 6-392 Fault Currents and Voltages in a Line Fed on Both Sides

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

6.44.4 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
- The residual compensation factors in setting format Kr and Kx

Parameter: Start

- Default setting (_:101) Start = with dropout

The Start parameter is used to define the criterion for starting the fault location. The following functions can start the fault locator:

- Overcurrent protection, phases or ground
- Directional overcurrent protection, phases or ground
- Instantaneous high-current tripping

Parameter Value	Description
with dropout	The fault-location calculation starts with the dropout of one of the protection functions listed previously.
with operate indication	If one of the protection functions listed previously generates an operate indication, calculation of the fault location starts.

As an alternative, the fault locator can be started using external binary input.

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.

Parameter: X per length unit

- Default setting (_:113) X per length unit = 0.210 Ω/km

With the X per length unit parameter you set the reactance per unit length for the line to be protected. You set the X per length unit parameter as a relative value in Ω/km or Ω/miles.

Parameter: Line length

- Default setting (_:114) Line length = 60 km

With the Line length parameter, you can set the length of the line to be protected as unit of length in km or miles.

Parameter: Line angle

- Default setting (_:108) Line angle = 85.00°

Calculate the setting value for the parameter Line angle from the line constants for the line to be protected as follows:

$$\tan\varphi = \frac{X_L}{R_L} \quad \text{or} \quad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

where:

R_L	Resistance of the line to be protected
X_L	Reactance of the line to be protected

EXAMPLE

110-kV overhead line, 150 mm² with the data:

R'_1 = 0.19 Ω/km

X'_1 = 0.42 Ω/km

You calculate the setting value for the line angle as follows:

$$\tan\varphi = \frac{X_L}{R_L} = \frac{X'_1}{R'_1} = \frac{0.42\ \Omega/km}{0.19\ \Omega/km} = 2.21$$

arctan (2.21) = 65.7°

Parameter: Kr and Kx

- Default setting (_:104) Kr = 1.00
- Default setting (_:105) Kx = 1.00

The Kr and Kx parameters are used to set the residual compensation factors as scalar values. The Kr and Kx parameters are relevant for the Fault locator function.

Calculate the setting values for the parameters Kr and Kx from the line data as follows:

Resistance ratio

$$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3}\cdot\left(\frac{R_0}{R_1} - 1\right)$$

Reactance ratio

$$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3}\cdot\left(\frac{X_0}{X_1} - 1\right)$$

where:

R_0	Zero-sequence system resistance of the line
X_0	Zero-sequence system reactance of the line
R_1	Positive-sequence system resistance of the line
X_1	Positive-sequence system reactance of the line

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. You can calculate the data both from the primary values and from the secondary values.

EXAMPLE

110-kV overhead line, 150 mm² with the data:

R_1/s	0.19 Ω/km positive-sequence system resistance
X_1/s	0.42 Ω/km positive-sequence system reactance
R_0/s	0.53 Ω/km zero-sequence system resistance
X_0/s	1.19 Ω/km zero-sequence system reactance
s	Line length

You receive the following setting values for the parameters Kr and Kx:

$$Kr = \frac{R_{gnd}}{R_L} = \frac{1}{3}\cdot\left(\frac{R_0}{R_1} - 1\right) = \frac{1}{3}\cdot\left(\frac{0.53\ \Omega/km}{0.19\ \Omega/km} - 1\right) = 0.60$$

$$Kx = \frac{X_{gnd}}{X_L} = \frac{1}{3}\cdot\left(\frac{X_0}{X_1} - 1\right) = \frac{1}{3}\cdot\left(\frac{1.19\ \Omega/km}{0.42\ \Omega/km} - 1\right) = 0.61$$

Parameter: K0 and Angle (K0)

- Default setting K0 = 1.000
- Default setting Angle (K0) = 0.00°

> **NOTE**
> The visibility of the K0 and Angle (K0) parameters depends on the selected setting format of the residual compensation factors. The parameters K0 and Angle (K0) only become visible after you have set the parameter Set. format residu. comp. = K0 for the device. The Set. format residu. comp. parameter can be found in the DIGSI 5 project tree under **Name of the device → Parameter → Device settings**.

The K0 and Angle (K0) parameters are used to set the complex residual compensation factor. Make sure that the line angle is set correctly because the device needs the line angle for calculation of the compensation components from the K0 factor. The complex residual compensation factor is defined by the value and the angle. You can calculate the complex residual compensation factor from the line data as follows:

$$\underline{K}_0 = \left|\frac{\underline{Z}_{gnd}}{\underline{Z}_L} = \frac{1}{3}\cdot\left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right|$$

where:

$\underline{Z}_0$	(complex) zero-sequence impedance
$\underline{Z}_1$	(complex) positive-sequence impedance

This data can either be used for the entire line or as length-related values, since the quotients are length-independent. The data can be calculated both from the primary values and from the secondary values.

For overhead lines, you can use the values for the calculation because the angles of the zero-sequence system and the positive-sequence system differ only slightly. For cables, however, significant angular differences can occur, as the following example illustrates.

EXAMPLE

110-kV single-conductor liquid-filled cable 3 · 185 mm² Cu with the data:

Z_1/s	0.408 · $e^{j73°}$ Ω/km positive-sequence impedance
Z_0/s	0.632 · $e^{j18.4°}$ Ω/km zero-sequence impedance
s	Line length

The values for calculation of the residual compensation factor K0 are:

$$\frac{\underline{Z}_0}{\underline{Z}_1} = \frac{0.632}{0.408}\cdot e^{j(18.4°-73°)} = 1.55\cdot e^{-j54.6°} = 1.55\cdot(0.579 - j0.815) = 0.898 - j1.263$$

$$\underline{K}_0 = \left|\frac{1}{3}\cdot\left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)\right| = \left|\frac{1}{3}\cdot(0.898 - j1.263 - 1)\right| = \left|\frac{1}{3}\cdot(-0.102 - j1.263)\right|$$

The setting value of the parameter K0 is calculated from:

$$K_0 = \left|\frac{1}{3}\cdot\sqrt{(-0.102^2) + (-1.263^2)}\right| = 0.42$$

When determining the angle, take note of the quadrant of the result. The following table lists the quadrants and the angle range obtained from the operational signs of the real and imaginary parts of K0.

Real Part	Imaginary Part	tan Phi (K0)	Quadrant/Range		Calculation Method
+	+	+	I	0° to 90°	arc tan (|Im| / |Re|)
+	-	-	IV	-90° to 0°	–arc tan (|Im| / |Re|)
-	-	+	III	-90° to -180°	arc tan (|Im| / |Re|) – 180°
-	+	-	II	+90° to +180°	–arc tan (|Im| / |Re|) +180°

In this example, the following setting value for the Angle (K0) parameter is obtained:

$$\varphi(k_0) = \arctan\left(\frac{1.263}{0.102}\right) - 180° = -94.6°$$

6.44.5 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
_:103	Fault locator:Load compensation		• no • yes	no
_:113	Fault locator:X per length unit	1 A	0.0001 Ω/km to 9.5000 Ω/km	Ω/km
		5 A	0.0002 Ω/km to 1.9000 Ω/km	0.0000 Ω/km
_:114	Fault locator:Line length		0.10 km to 1000.00 km	60.00 km
_:108	Fault locator:Line angle		10.00° to 89.00°	85.00°
_:104	Fault locator:Kr		0.33 to 11.00	1.00
_:105	Fault locator:Kx		0.33 to 11.00	1.00
_:118	Fault locator:K0		0.000 to 11.000	1.000
_:150	Fault locator:Angle (K0)		-180.00° to 180.00°	0.00°

6.44.6 Information List

No.	Information	Data Class (Type)	Type
Fault locator			
_:54	Fault locator:Inactive	SPS	O
_:52	Fault locator:Behavior	ENS	O
_:53	Fault locator:Health	ENS	O
_:302	Fault locator:Fault resistance prim.	MV	O
_:303	Fault locator:Fault reactance prim.	MV	O

No.	Information	Data Class (Type)	Type
_:308	Fault locator:Fault resistance sec	MV	O
_:309	Fault locator:Fault resistance sec.	MV	O
_:304	Fault locator:Fault distance	MV	O
_:305	Fault locator:Fault distance in %	MV	O
_:306	Fault locator:Fault loop	ENS	O
_:307	Fault locator:FL invalid	ENS	O

6.45 Temperature Supervision

6.45.1 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.

6.45.2 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.

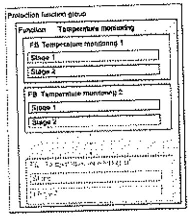

Figure 6-303 Structure/Embedding of the Function

6.45.3 Function Description

Logic

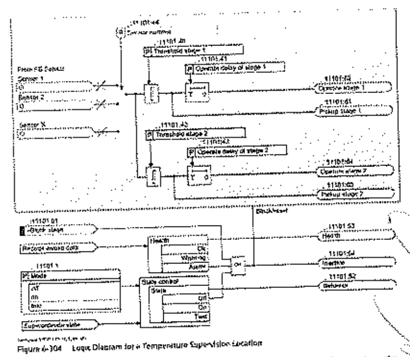

Figure 6-304 Logic Diagram for a Temperature Supervision Location

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.

6.45.4 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 5.6.7.3 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 in the medium in which the temperature measurement takes place.

Parameter: Sensor number

- Default setting (_:11101:44) Sensor number = no function block selected

With the Sensor number parameter, you assign a specific sensor whose temperature is to be monitored to the Location function block. You perform the assignment in DIGSI using a list box that contains all connected RTD units and their sensors.

Parameter: Threshold stage 1

- Default setting (_:11101:40) Threshold stage 1 = 100°C

With the Threshold stage 1 parameter you establish the temperature value whose exceedance causes a pickup of the 1st tripping stage.

Parameter: Operate delay of stage 1

- Default setting (_:11101:41) Operate delay of stage 1 = 5 s

With the Operate delay of stage 1 parameter you establish the time the operate indication of the 1st tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Parameter: Threshold stage 2

- Default setting (_:11101:42) Threshold stage 2 = 120°C

With the Threshold stage 2 parameter you establish the temperature value whose exceedance causes a pickup of the 2nd tripping stage.

Parameter: Operate delay of stage 2

- Default setting (_:11101:43) Operate delay of stage 2 = 0 s

With the Operate delay of stage 2 parameter you establish the time the operate indication of the 2nd tripping stage should be delayed after the pickup. This time delay depends on the specific application. If you set the time delay to ∞ the operate indication is blocked.

Temperature Unit

Temperature Unit To change the display and evaluation of measured temperature values from °C to °F, adapt the DIGSI user default settings accordingly (see 5.6.7.5 Temperature Sensor).

6.45.5 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

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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	

6.45.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:53	General:Health	ENS	O
Point 1			
_:11101:81	Point 1:>Block stage	SPS	I
_:11101:54	Point 1:Inactive	SPS	O
_:11101:52	Point 1:Behavior	ENS	O
_:11101:53	Point 1:Health	ENS	O
_:11101:61	Point 1:Pickup stage 1	SPS	O
_:11101:62	Point 1:Operate stage 1	SPS	O
_:11101:63	Point 1:Pickup stage 2	SPS	O
_:11101:64	Point 1:Operate stage 2	SPS	O
Point 2			
_:11102:81	Point 2:>Block stage	SPS	I
_:11102:54	Point 2:Inactive	SPS	O
_:11102:52	Point 2:Behavior	ENS	O
_:11102:53	Point 2:Health	ENS	O
_:11102:61	Point 2:Pickup stage 1	SPS	O
_:11102:62	Point 2:Operate stage 1	SPS	O
_:11102:63	Point 2:Pickup stage 2	SPS	O
_:11102:64	Point 2:Operate stage 2	SPS	O
Point 3			
_:11103:81	Point 3:>Block stage	SPS	I
_:11103:54	Point 3:Inactive	SPS	O
_:11103:52	Point 3:Behavior	ENS	O
_:11103:53	Point 3:Health	ENS	O
_:11103:61	Point 3:Pickup stage 1	SPS	O
_:11103:62	Point 3:Operate stage 1	SPS	O
_:11103:63	Point 3:Pickup stage 2	SPS	O
_:11103:64	Point 3:Operate stage 2	SPS	O
Point 4			
_:11104:81	Point 4:>Block stage	SPS	I
_:11104:54	Point 4:Inactive	SPS	O
_:11104:52	Point 4:Behavior	ENS	O
_:11104:53	Point 4:Health	ENS	O
_:11104:61	Point 4:Pickup stage 1	SPS	O
_:11104:62	Point 4:Operate stage 1	SPS	O
_:11104:63	Point 4:Pickup stage 2	SPS	O
_:11104:64	Point 4:Operate stage 2	SPS	O
Point 5			
_:11105:81	Point 5:>Block stage	SPS	I
_:11105:54	Point 5:Inactive	SPS	O
_:11105:52	Point 5:Behavior	ENS	O
_:11105:53	Point 5:Health	ENS	O
_:11105:61	Point 5:Pickup stage 1	SPS	O

No.	Information	Data Class (Type)	Type
_:11105:62	Point 5:Operate stage 1	SPS	O
_:11105:63	Point 5:Pickup stage 2	SPS	O
_:11105:64	Point 5:Operate stage 2	SPS	O
Point 6			
_:11106:81	Point 6:>Block stage	SPS	I
_:11106:54	Point 6:Inactive	SPS	O
_:11106:52	Point 6:Behavior	ENS	O
_:11106:53	Point 6:Health	ENS	O
_:11106:61	Point 6:Pickup stage 1	SPS	O
_:11106:62	Point 6:Operate stage 1	SPS	O
_:11106:63	Point 6:Pickup stage 2	SPS	O
_:11106:64	Point 6:Operate stage 2	SPS	O
Point 7			
_:11107:81	Point 7:>Block stage	SPS	I
_:11107:54	Point 7:Inactive	SPS	O
_:11107:52	Point 7:Behavior	ENS	O
_:11107:53	Point 7:Health	ENS	O
_:11107:61	Point 7:Pickup stage 1	SPS	O
_:11107:62	Point 7:Operate stage 1	SPS	O
_:11107:63	Point 7:Pickup stage 2	SPS	O
_:11107:64	Point 7:Operate stage 2	SPS	O
Point 8			
_:11108:81	Point 8:>Block stage	SPS	I
_:11108:54	Point 8:Inactive	SPS	O
_:11108:52	Point 8:Behavior	ENS	O
_:11108:53	Point 8:Health	ENS	O
_:11108:61	Point 8:Pickup stage 1	SPS	O
_:11108:62	Point 8:Operate stage 1	SPS	O
_:11108:63	Point 8:Pickup stage 2	SPS	O
_:11108:64	Point 8:Operate stage 2	SPS	O
Point 9			
_:11109:81	Point 9:>Block stage	SPS	I
_:11109:54	Point 9:Inactive	SPS	O
_:11109:52	Point 9:Behavior	ENS	O
_:11109:53	Point 9:Health	ENS	O
_:11109:61	Point 9:Pickup stage 1	SPS	O
_:11109:62	Point 9:Operate stage 1	SPS	O
_:11109:63	Point 9:Pickup stage 2	SPS	O
_:11109:64	Point 9:Operate stage 2	SPS	O
Point 10			
_:11110:81	Point 10:>Block stage	SPS	I
_:11110:54	Point 10:Inactive	SPS	O
_:11110:52	Point 10:Behavior	ENS	O
_:11110:53	Point 10:Health	ENS	O
_:11110:61	Point 10:Pickup stage 1	SPS	O
_:11110:62	Point 10:Operate stage 1	SPS	O

No.	Information	Data Class (Type)	Type
_:11110:63	Point 10:Pickup stage 2	SPS	O
_:11110:64	Point 10:Operate stage 2	SPS	O
Point 11			
_:11111:81	Point 11:>Block stage	SPS	I
_:11111:54	Point 11:Inactive	SPS	O
_:11111:52	Point 11:Behavior	ENS	O
_:11111:53	Point 11:Health	ENS	O
_:11111:61	Point 11:Pickup stage 1	SPS	O
_:11111:62	Point 11:Operate stage 1	SPS	O
_:11111:63	Point 11:Pickup stage 2	SPS	O
_:11111:64	Point 11:Operate stage 2	SPS	O
Point 12			
_:11112:81	Point 12:>Block stage	SPS	I
_:11112:54	Point 12:Inactive	SPS	O
_:11112:52	Point 12:Behavior	ENS	O
_:11112:53	Point 12:Health	ENS	O
_:11112:61	Point 12:Pickup stage 1	SPS	O
_:11112:62	Point 12:Operate stage 1	SPS	O
_:11112:63	Point 12:Pickup stage 2	SPS	O
_:11112:64	Point 12:Operate stage 2	SPS	O

6.46 Current-Jump Detection

6.46.1 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. Pickup of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.46.2 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.

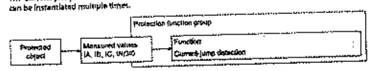

Figure 6-305 Structure/Embedding of the Function

6.46.3 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 first 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 to a 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 N information. If the current-jump detection responds ($\Delta I_{>}$), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value (ΔI_{dyn}) in accordance with the logic in Figure 6-306. 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.

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Logic

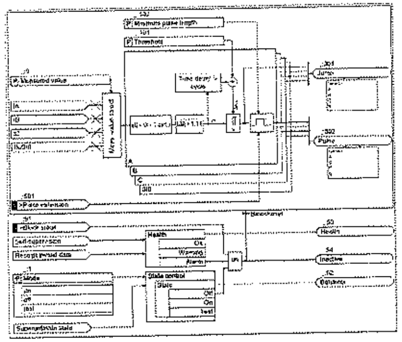

Figure 6-306 Current-Jump Detection Logic

6.46.4 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 = 0.10 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.

6.46.5 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		0.01 s to 60.00 s	0.10 s

6.46.6 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

6.47 Voltage-Jump Detection

6.47.1 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 logics. Pickup of the function therefore neither opens a separate fault in the fault log nor generates an operate indication.

6.47.2 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.

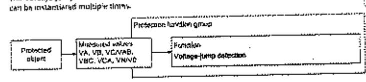

Figure 6-307 Structure/Embedding of the Function

6.47.3 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 included the separate phase information. If you have selected the zero sequence voltage for measurement, the output indication data type used includes the N information. If the voltage-jump detection responds ($\Delta V_{(xx)}$), the general information is generated in the output indication in all cases.

Dropout occurs with a dynamically increased threshold value $\Delta U_{(xx)}$ in accordance with the information in Figure 6-308. 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

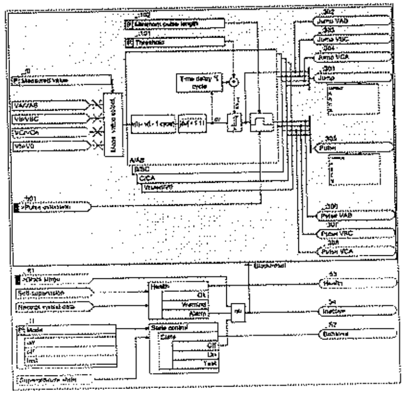

Figure 6-308 Voltage-Jump Detection Logic

6.47.4 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
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.

6.47.5 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
_:102	V-jump det. #:Minimum pulse length		0.01 s to 60.00 s	0.10 s

6.47.6 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
_:308	V-jump det. #:Pulse VCA	SPS	O

6.48 Voltage Measuring-Point Selection

6.48.1 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.

6.48.2 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 >MP-ID selection depending on the switch positions of disconnectors.

Example

Figure 6-309 shows an example of voltage measuring points selection for the function group Capacitor bank in a double busbar application.

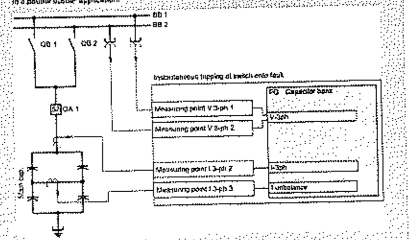

Figure 6-309 Double Busbar with Capacitor Bank

Connecting Measuring Points to Capacitor Bank Function Group

Figure 6-310 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.

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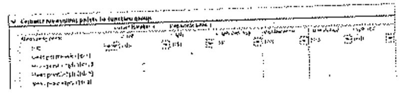

Figure 6-310 Connecting the Measuring Points with the Capacitor Bank Function Group

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 points.

6.48.3 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 >MP-ID selection of the function block.

The following logic block chart implementation is based on the example given in Figure 6-309.

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 >MP-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 6-311 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 IN3 of the block bool_in[_1 becomes true, the value 0 is used as the ID for voltage selection input (>MP-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 from one or the other busbar, you can alter the CFC chart respectively.

> **NOTE**
> An invalid measuring-point selection (ID = 0 or an ID of a unconnected measuring point) for input >MP-ID 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.

6.48.4 Information List

No.	Information	Data Class (Type)	Type
V-MP selection			
_:501	V-MP selection:>MP-ID selection	INS	I
_:53	V-MP selection:Health	ENS	O
_:301	V-MP selection:Selection invalid	SPS	O

7 Capacitor Bank Protection

7.1 Introduction

Capacitors and capacitor banks are used for various applications. Examples are:

- Reactive-power compensation for voltage stabilization
- Fast voltage- and reactive-power control
- Filter circuits for the elimination of certain frequencies

Capacitor banks for transmission systems are complex systems customized for the special application. The design depends much on the used switching technology (for example, mechanically or via thyristor). In detail hardly one capacitor bank resembles another. However, a capacitor bank consists always of the same components (C, R, L, and switches). A capacitor bank often consists of several subcomponents which are connected to the capacitor-bank busbar via the circuit breakers.

The modularity of hardware and protection functionality allows to tailor the protection device exactly to the needs of the capacitor bank or the subcomponent of the capacitor bank and to realize the complete protection of the whole capacitor bank or the capacitor- bank subcomponent with only one 7SJ8 device.

Capacitor banks require the use of extensive protection functionality. The protection consists of standard protection functions and specific capacitor protection functions. The following topics are described in the next chapters:

- Extensions on standard protection functions for optimal utilization in a capacitor bank
- Specific capacitor protection functions
- Application of standard protection functions for specific protection tasks within a capacitor bank

7.2 Overcurrent Protection for Capacitor Banks

7.2.1 Overview

You can use the following overcurrent protection function types in the **Capacitor Bank** function group:

- **Overcurrent protection, phases** with phase-segregated operate indications for short-circuit protection in the area between the busbar and the capacitor and for protecting against overload of a subbank.
- **Overcurrent protection, phases** for protection against overload of RLC filter circuit elements (**Overcurrent -3ph RLC**)
- **Overcurrent protection, ground** as protection or backup protection in the event of ground faults

Figure 5-15 in Chapter 5.4.2 Structure of the Function Group shows:

- The standard protection functions that you can use in the **Capacitor Bank** function group.
- The specific protection functions that are available for protecting a capacitor bank.
- The assignment of protection functions to the interfaces of the function group.

Figure 5-13 in Chapter 5.4.2 Structure of the Function Group shows the assignment of the interfaces in the **Capacitor Bank** function group to the measuring points of the device with reference to an example.

> **NOTE**
> The structure of the function **Overcurrent protection, Phases for protecting RLC elements of a filter circuit** differs only slightly from the standard function **Overcurrent protection, Phases – Advanced**.
> In this chapter, only the differences between this and the standard function are described.
> For more information, please refer to the function description **Overcurrent protection, Phases** starting from Chapter 6.x.1 Overview of Functions .

> **NOTE**
> Starting from V07.30, the function type **50/51 OC-3ph** 1p is no longer offered in the DIGSI 5 global library in the function group **Capacitor bank**. Instead you can use now the standard advanced overcurrent function **Overcurrent protection, phases – advanced** to apply phase segregated operate indications.

7.2.2 Overcurrent Protection, Phases for Protection of RLC Filter-Circuit Elements

7.2.2.1 Structure of the Function

In the **Capacitor Bank** function group, the **Overcurrent protection, Phases for protecting RLC filter circuit elements** function (**Overcurr. -3ph RLC**) is based on the standard protection function **Overcurrent protection, Phases – Advanced**.

The **Overcurrent protection, Phases for protecting RLC filter circuit elements** function differs from the standard protection function as follows:

- Superordinate measuring point selection
- Setting the rated current of the protected object (for example, reactor or resistor) within the function
- Measured function values of connected phase currents

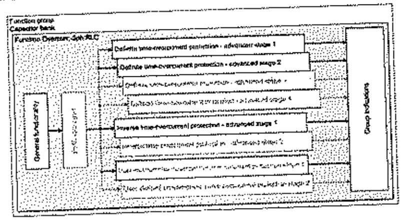

Figure 7-1 Structure/Embedding of the Overc. -3-Ph RLC Function

7.2.2.2 Description

A feature of the **Overcurrent -3ph RLC** function is the **selection of measuring points**. A capacitor bank can include multiple filter circuits. Each filter can include, for example, a 3-phase current measurement device, each of which is assigned a measuring point. In order to protect the filter circuits, multiple instances of the **Overcurrent -3ph RLC** function can be created. Each instance of the function is assigned to a measuring point via **Measuring point selection**.

The function is structured such that the **Measuring point selection** is superordinate to the advanced overcurrent-protection stages.

Measuring-Point Selection

With the MP selection parameter, you can select from a list of measuring points a measuring point that is connected to the I-3ph RLC interface in the Capacitor Bank function group. The **Overcurrent -3ph RLC** function processes the current that is connected to the measuring point.

For more information, refer to the description of the **Capacitor Bank** function group starting from chapter 5.4.1 Overview.

Rated Current of the Protected Object

The rated current for the whole capacitor bank is set in the **Capacitor Bank** function group. However, the capacitor bank rated current does not apply for individual reactors or resistors used within a capacitor-bank installation. Such reactors or resistors require an individual rated current setting.

Functional Measured Values

The function provides the connected phase currents as measured function values for display, further processing or transmission to a station.

Values	Description	Primary	Secondary	% Referenced to
Iph:A Iph:B Iph:C	Phase current of measuring point	kA	A	% referenced to parameter RLC rated current

You can find the parameter **RLC Rated current** in the function block **General** of the **Overcurrent -3ph RLC** function.

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7.2.2.3 Application and Setting Notes

Parameter: MP selection

- Default setting (_:13502) MP selection = No meas. point config.

With the MP selection parameter, you can select a measuring point that is connected to the I 3ph RLC interface in the Capacitor bank function group.
The selection list displays the measuring points that are connected to the I 3ph RLC interface of the Capacitor bank function group:

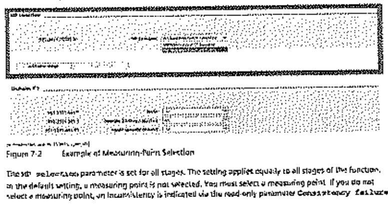

Figure 7-2 Example of Measuring-Point Selection

The MP selection parameter is set for all stages. The setting applies equally to all stages of the function. In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter Consistency failure:

Figure 7-3 Function Inconsistency Indication

Parameter: RLC Rated Current

- Default setting (_:2311:101) RLC rated current = 1000 A

The parameter RLC rated current is used to set the primary rated current of the respective protected object which is usually a reactor or resistor branch within the capacitor bank installation. The RLC rated current specified here is the reference value for the percentage-measured values and setting values made in percentages.

7.3 Thermal Overload Protection for Capacitor Banks

7.3.1 Overview of Functions

The function Overload RLC protects RLC filter circuit elements in a capacitor bank from thermal overload.

NOTE

The structure of the function Overload RLC differs only slightly from that of the standard Thermal overload protection, 3-phase function. In this chapter, only the differences between these and the standard function are described.
For more information, refer to the function description Thermal overload protection, 3-phase starting from chapter 6.19.1 Overview of Functions.

7.3.2 Structure of the Function

The function Overload protection RLC is used in the Capacitor bank function group.
The General functionality differs from the standard Thermal overload protection function and consists of:

- Measuring point selection
- Setting the rated current of the protected object (for example, reactor or resistor) within the function

Figure 7-1 Structure/Embedding of the Function

7.3.3 Description

A feature of the function Overload RLC is the measuring-point selection. A capacitor bank can include multiple filter circuits. Each filter can include, for example, a 3-phase current measurement device, each of which is assigned a measuring point. In order to protect all filter circuits, multiple instances of the function Overload RLC can be created. Each instance of the function is assigned to a measuring point via measuring-point selection.
The function is structured such that the measuring-point selection is superordinate to the Thermal overload protection.

Measuring-Point Selection

With the parameter MP selection, you can select from a list of measuring points a measuring point that is connected to the I 3ph RLC interface in the Capacitor bank function group. The function Overload RLC processes the current that is connected to the measuring point.
For more information, refer to the description of the Capacitor bank function group starting from Chapter 5.4.1 Overview.

Rated Current of the Protected Object

The rated current for the whole capacitor bank is set in the Capacitor Bank function group. However, the capacitor bank rated current does not apply for individual reactors or resistors used within a capacitor bank installation. Such reactors or resistors require an individual rated current setting.

Function Values

Measured Values	Description	Primary	Secondary	% Referred to
(_:601:304) Time until close	Time until close	s	s	s
(_:601:305) Time until trip	Estimated time until trip	s	s	s
(_:601:306) Overload phase A	Thermal measured values of phases	%	%	Trip temperature
(_:601:307) Overload phase B				
(_:601:308) Overload phase C				
(_:601:309) Overload maximum	Thermal measured values of overload protection	%	%	Trip temperature
(_:601:310) Equival. current phs A	Current measured value as basis for overload measured value	A	A	Parameter RLC rated current
(_:601:311) Equival. current phs B				
(_:601:312) Equival. current phs C				
(_:601:313) Equival. current max.	Maximum current measured value as base for overload value	A	A	Parameter RLC rated current

7.3.4 Application and Setting Notes

Parameter: MP selection

- Default setting (_:13501) MP selection = no MP configured

With the MP selection parameter, you can select a measuring point that is connected to the I 3ph RLC interface in the Capacitor bank function group.
The selection list displays the measuring points that are connected to the I 3ph RLC interface of the Capacitor bank function group:

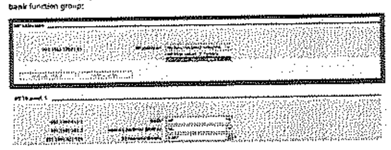

Figure 7-5 Example of Measuring Point Selection

The MP selection parameter is set for all stages. The setting applies equally to all stages of the function. In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter Consistency failure :

Figure 7-6 Function Inconsistency Indication

Parameter: RLC rated current

- Default setting RLC rated current = 1000 A

The parameter RLC rated current is used to set the primary rated current of the respective protected object which is usually a reactor or resistor branch within the capacitor bank installation. The setting is used as I_{rated} for the normalization calculation within the thermal model.

7.3.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:RLC rated current		1 A to 100000 A	1000 A
MP selection				
_:13501:100	MP selection:Consistency failure		• no MP configured • no Sensor configured	no MP configured
_:13501:81	MP selection:MP selection		Setting options depend on configuration	

7.3.6 Information List

No.	Information	Data Class (Type)	Type
MP selection			
_:13501:301	MP selection:3ph	WYE	O

7.4 Current-Unbalance Protection for Capacitors, 3-Phase

7.4.1 Overview of Functions

The Current-unbalance protection for capacitors, 3-phase function (ANSI 60C):

- Protects in case of capacitor elements (C-elements) faults of a capacitor bank in H connection
- Provides very sensitive supervision of the unbalanced current between the 2-star points
- Allows counting of individual faulty C elements

7.4.2 Structure of the Function

The Current-unbalance protection for capacitors, 3-phase function is used in the Capacitor bank function group. It is preconfigured at the factory with 2 overcurrent-protection stages I> and one stage of the type Counter. A maximum of 3 overcurrent-protection stages and 4 counter stages can be operated simultaneously in the function.
The function is designed so that the General functionality (including compensation) and the Measuring-point selection can work across the stages.

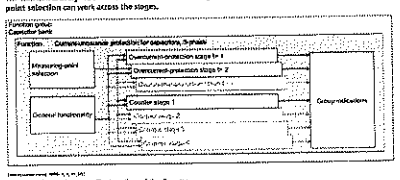

Figure 7-7 Structure/Embedding of the Function

7.4.3 General Functions and Measuring-Point Selection

7.4.3.1 Description

The General functionality is structured in the following functional parts.

- Compensation of the unbalance
- Normalization of the unbalanced current with the current I_c
- Counting faulty C-elements (the stage type Counter is used to monitor the counter status)

Logic for Compensation and Normalization

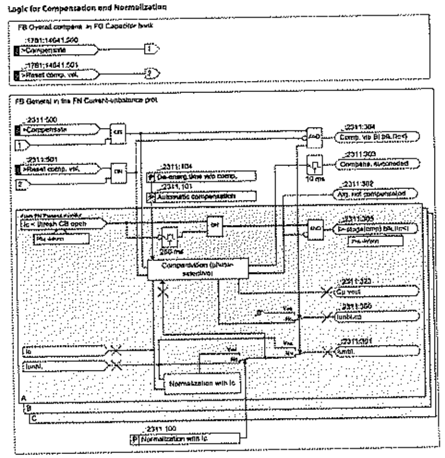

Figure 7-8 Cross-Stage Functionality

Measuring-Point Selection

With the MP selection parameter, you can select from a list of measuring points a measuring point that is connected to the I Unbalanced interface in the Capacitor bank function group. The Current-unbalance protection for capacitors, 3-phase function processes the current that is connected to the measuring point.
For more information, refer to the description of the Capacitor bank function group starting from Chapter 5.4.1 Overview.

Measurands, Method of Measurement

The function receives its measurands via the I Unbalanced interface of the Capacitor bank function group.

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The compensated and non-compensated unbalanced currents are provided for the overcurrent-protection stage. Within the protection stage, one of the 2 values is selected in the protection stage via the parameter Unbalanced value. Both values are available as functional measured values (see Figure 7-8).

Configure across the stages whether the unbalanced current must be normalized with the current I_c that flows into the capacitor bank. You can find more information in this chapter under *Normalization with I_c*, Page 926.

The method of measurement used processes the sampled unbalanced-current values and filters out the fundamental component numerically. The protection stages evaluate the fundamental component of the unbalanced current.

General Notes on the Compensation

An operational unbalanced current is added to an unbalanced current resulting from faulty capacitor elements. This corrupts the measuring result.

Operational unbalanced currents can result from the following causes:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates operational unbalanced currents by calculation. For this purpose, the phasor of the operational unbalanced current $I_{unbal,op}$ is stored at specific times. The stored phasor (compensation phasor) is subtracted from the actually measured unbalanced-current phasor:

$$I_{unbal,comp.} = I_{unbal} - I_{unbal,op.}$$

The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. The compensated values are not available under the following conditions: • After initial startup of the device before any compensation is carried out • After activating the binary input >Reset comp. val. • After change of I_{rated} Protection stages that are working with compensated values are inactive.
Compens. succeeded	This indication is issued (as transient indication with a pulse duration of 10 ms) if the existing unbalance has been compensated manually or automatically. In case of automatic compensation, the signal is issued at each event-based situation where full compensation is carried out.
Comp. via BI blk.(Ic<)	If a manual compensation has been initiated and the current I_c (current flowing into the capacitor bank) at this time is less than the threshold Current thresh. CB open, the manual compensation is not executed. This is signaled via the Comp. via BI blk.(Ic<) indication.

2 different methods are available for the compensation:

- Manual compensation via binary input signals
- Automatic compensation

Manual Compensation via Binary Input Signal

If the binary input signal >Compensate is activated, the manual compensation starts. This will fully compensate any unbalance that exists at this time. This means the value $I_{unbal,comp.}$ will then become 0. You can also use the manual compensation in parallel with the automatic compensation.

Automatic Compensation

When using the parameter Automatic compensation, this automatic compensation function can be enabled or disabled.

The automatic compensation consists of 2 different mechanisms:

- The event based compensation of any existing unbalance.
  This compensation is performed in the following situations:
  - After energizing the capacitor bank or a phase of the bank (phase-selective compensation)
  - After counting a faulty C-element (phase-selective compensation)
  - After each startup of the device
  - After specific parameter changes:
    - Switching on the automatic compensation
    - Changing the rated current of the capacitor bank

  In order to avoid transient inrush-current effects, the compensation is delayed by 250 ms after energizing has been detected.
  Full compensation after bank energization can be avoided in case of only short de-energization by means of parameter De-energ. time w/o comp.. If the de-energized duration is less than the setting of parameter De-energ. time w/o comp., the full compensation is not carried out after energizing a phase or the whole bank.
- Cyclic, slow and thus gradual compensation of an existing unbalance in small increments.
  This permits, for example, the automatic compensation of environmental influences.

Resetting the Compensation

The algorithm can be reset to the non compensated status. Compensated values are not available in this case. Protection stages that work with compensated values are rendered inactive. The binary input signal >Reset comp. val. of the function or function group resets the compensation (see also Figure 7-8).

> **NOTE**
> When operating with manual compensation, changing the value of parameter Capacitor reference current will reset the compensation values.

Normalization with I_c

The threshold for the unbalanced current is usually set by assuming the rated capacitor current $I_{c,rated}$. The current I_c flowing into the capacitor bank determines the amount of the unbalanced current. A lower I_c also means a lower unbalanced current. If $I_c < I_{c,rated}$, the protection becomes less sensitive. This influence can be compensated via the normalization. Normalization keeps the sensitivity of the protection function constant by normalizing the unbalance value with the current I_c. When using the parameter Normalization with Ic, normalization is enabled or disabled.

I_c Lower than Current Thresh.CB Open

If the current I_c is lower than the threshold Current Thresh.CB Open, the compensated value can no longer be computed with sufficient accuracy. To avoid a malfunction, the compensated unbalanced value $I_{unbal,comp.}$ is set to 0 A in a phase-segregated way (see Figure 7-8). This deactivates the affected phase measuring components of the protection stages that work with compensated values.

This condition will be indicated in a phase-segregated manner (indication I>-stage(cmp) blk.(Ic<)). In this case, normalization with current I_c will no longer work properly either. The normalization is canceled in a phase-segregated manner. This means that the non-normalized value is used in place of the normalized value (see Figure 7-8).

Charging/Energizing the Capacitor Bank or a Phase of the Bank

Charging of the bank takes place when the discharged bank is switched on to the network. Charging of a phase can occur in case of network faults. If a phase to ground voltage drops to 0 V due to a network fault, the respective phase is discharged and the return of the phase-to-ground (after the fault has been cleared) will charge the phase.

Charging the bank or a phase of the bank causes inrush currents in the respective phases. To avoid overfunction in case of sensitive threshold settings, the stages using compensated unbalanced values are blocked in a phase selective way by setting $I_{unbal,comp.}$ to 0 A. These stages are:

- Counter stage
- I>-stage, if set to operate with compensated unbalanced values

The blocking ($I_{unbal,comp.}$ set to 0 A) lasts for 250 ms after energizing detection. Afterwards, the calculated $I_{unbal,comp.}$ is processed again.

Energizing detection takes place in a phase-selective way by monitoring the phase current I_c flowing into the bank. If a phase current exceeds the threshold Current Thresh. CB Open, energizing in this phase is detected.

Logic for Counting Faulty C-Elements

This part of the General functionality is only important if counter stages are used.

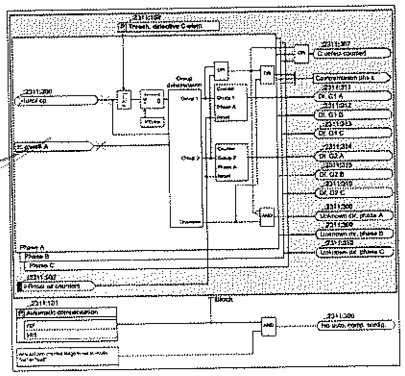

Figure 7-9 Counting Faulty C Elements

Activation/Blocking Counting

If at least one counter stage is enabled, the counter function is active. Furthermore, the counter function works only if the automatic compensation is enabled.

In order to prevent counting as a consequence of the charging process, the counter function is implicitly blocked for 250 ms by setting $I_{unbal,comp.}$ to 0 A, after the capacitor energizing has been detected.

Measurands, Counting

The measurand is the phase-selective compensated unbalanced current $I_{unbal,comp.}$. If a single C-element is faulty, an unbalance occurs in the H connection. This unbalance causes an unbalanced current; this means, a small current jump is generated in the unbalanced current. Set the parameter Thresh. defective C-elem. so that the current jump can be detected (refer also to 7.4.3.2 Application and Setting Notes). The unbalanced current that was caused by the fault must exceed the threshold for 100 ms before the affected group is determined and counting (incrementing the counter) takes place. There is one counter for each phase and group. After the counting, the existing unbalance is compensated; this means, the unbalance is reset to 0 A. If the faulty group cannot be determined, the unbalance is also compensated.

Resetting/Setting the Counters

You can reset or set the counters of group 1 and group 2 via:

- On-site operation panel directly on the device
- Online DIGSI connection to the device
- Binary input >Reset all counters (only reset of all counters)
- Communication connection with the control center

You can directly set or reset the counters via IEC 61850 by setting the counter values to the desired value. If you want to reset the counters via DNP3, IEC 60870-5-103, Modbus, or IEC 60870-5-104, an additional configuration with CFC is necessary. For more information, refer to chapter *7.4.3.2 Application and Setting Notes*.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:300) Iunbal.cp	Compensated unbalanced current $I_{unbal,comp.}$	kA	A	Parameter Rated primary current
(_:2311:301) Iunbal.	Non-compensated unbalanced current I_{unbal}	kA	A	Parameter Rated primary current
(_:2311:323) Cp.vect.	Compensation vector $I_{unbal,comp.}$	kA	A	Parameter Rated primary current

You can find the value of the parameter Rated primary current of the preceding table in the chapter 6.?.6 Settings according to the specified parameter MP selection.

$I_{unbal,comp.}$ is normalized with I_c. The normalization is carried out no matter if the parameter Normalization with Ic is set to yes or no. $I_{unbal,comp.}$ keeps its value unchanged until the next compensation occurs.

$$I_{comp,vect} = I_{unbal,m} \cdot \frac{I_{c,rated}}{I_c}$$

Where:

$I_{unbal,m}$	Operational unbalanced current at the moment the compensation is carried out
$I_{c,rated}$	Rated current of the capacitor bank
I_c	Current of the capacitor bank at the moment the compensation is carried out

Definition of the Group and Fault Location with the Capacitor in H Connection

If the capacitor is designed in an H connection, the following definition is assumed:

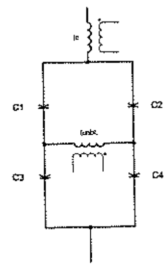

Figure 7-10 Definition of the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1 and C4
- Group 2: C2 and C3

In order to determine the fault location (group 1 or 2) correctly, use the parameter Capacitor element type (in FB General of the Capacitor bank function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

The angle reference of the unbalanced current phasor to the reference current I_c is used to determine the direction of the unbalanced current and, thus, the affected group is determined. If the direction cannot be determined with confidence, an appropriate indication will be generated.

7.4.3.2 Application and Setting Notes

Parameter: MP selection

- Default setting (_:15501:81) MP selection = None

With the MP selection parameter, you can select from a list the measuring point that is connected to the I Unbalanced interface of the Capacitor bank function group.

The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter Consistency failure.

Parameter: Automatic compensation

- Default setting (_:2311:101) Automatic compensation = no

The parameter applies equally to all stages of the function that work with compensated measurands.

ВЯРНО С ОРИГИНАЛА

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If no counter stages are applied, Siemens recommends switching the automatic compensation off and using the manual compensation. You can find more information on this recommendation in chapter 7.4.4.2 Application and Setting Notes (setting notes for the operate delay of the 1st stage).

If the counter stages are applied, the automatic compensation must be switched on, otherwise the counting function will not work.

Parameter: De-energ. time w/o comp.

- Default setting (_:2311:101) De-energ.time w/o comp. = 2.00 s

In case of network faults, the faulty phases are discharged. With the returning voltage after fault clearance, charging takes place. For such conditions, Siemens recommends that an automatic full compensation takes place in the affected phases. Otherwise, C-element defects occurring in this period (for example, because of discharging stress due to network-fault inception) will not be detected.

With the parameter De-energ. time w/o comp., you define the duration of short de-energization after which no automatic compensation takes place. The parameter must be set to a value larger than the slowest fault clearing time in your network plus a safety margin.

If the setting is set to 0 s, an automatic full compensation is carried out after each energizing detection.

Parameter: Normalization with Io

- Default setting (_:2311:100) Normalization with Io = no

This parameter applies equally to all stages of the function.

Parameter Value	Description
no	Select this setting if you can safely assume that I_c will not change for operational reasons or if you do not desire normalization of the unbalanced current with I_c. Please consider that the protection sensitivity will decrease with decreasing I_c.
yes	Select this setting if you want to keep the sensitivity of the protection stages constant during changes of I_c.

Parameter: Thresh. defective C-elem.

- Default (_:2311:102) Thresh. defective C-elem. = 0.030 A

Set the parameter Thresh. defective C-elem. to ensure that the jump in the unbalanced current caused by the faulty C-element is detected. Information about occurring unbalanced current as a consequence of single faulty C-elements will be provided by the manufacturer of the capacitor bank. Siemens recommends to set the threshold value to approx. 75 % of the unbalanced current that occurs after the fault of the 1st C-element.

Example 1: Information about the Unbalanced Current Available from the Manufacturer of the Capacitor Bank

Table 7-1 Unbalanced Current, Depending on the Number of Faulty C-Elements

Number of Faulty C-Elements	Primary Unbalanced Current
0	0.00 A
1	0.71 A
2	1.47 A
3	2.29 A
...	...

Assumed current transformer ratio: 10 A/1 A

Primary unbalanced current if 1st C-element fails: 0.71 A

Secondary unbalanced current if 1st C-element fails: 0.071 A

Secondary setting value: 0.75 · 0.071 A = 0.053 A

NOTE

Use sensitive device current inputs in order to apply secondary thresholds of < 30 mA.

If no information is provided by the manufacturer of the capacitor bank, the following example can be used as a basis in order to determine the value.

Example 2 (a to h): Unbalanced-Current Information Not Available from the Manufacturer of the Capacitor Bank, External Capacitor-Bank Structure with Cross-Linked Cans

The following consideration applies to one phase.

2a) External Structure of the Capacitor Bank

The external structure of the capacitor bank must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following external structure of the capacitor bank:
- 28 levels (cans) in series
- 4 cans per level
- H transformer between levels 13 and 14, counting from top to bottom
- 2 parallel cans are always cross-linked, refer to the following diagram

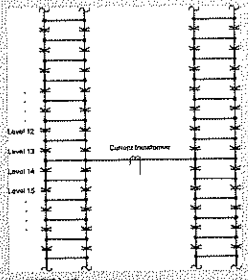

Figure 7-11 External Structure of the Capacitor Bank

2b) Internal Structure of a Can

The internal structure of a can must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following internal structure of the can:
- 14 parallel capacitances
- Internal fuses (one internal fuse per capacitance)
- 7 capacitance levels in series

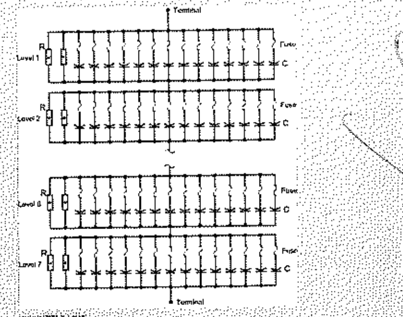

Figure 7-12 Internal Structure of a Can

2c) Capacitance of a Can

The capacitance of a can must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

- Capacitance per can: C_K = 19.67 μF

2d) Current per Phase

The unbalanced current is derived under the assumption of a certain phase current.

In this example, the phase current is determined using the following assumptions and data:

- 1-phase rated capacitance of the capacitor bank: 2.81 μF
- Phase-to-ground voltage of the fundamental component of the capacitor bank: 249.1 kV
- Current per phase: $I_c = V_{ph,fund} \cdot \omega C$ = 249.1 kV · 2π · 50 Hz · 2.81 μF = 219.9 A

2e) Capacitance of a Can during an Element Fault

To do this, the capacitance of an individual C-element will be determined first:

- Capacitance of a C-element:

$$C_E = \frac{C_K}{\text{No. C in parallel}} \cdot \text{No. C in series} = \frac{19.67\ \mu F}{14} \cdot 7 = 9.835\ \mu F$$

- Capacitance of a can during an element fault:

$$\frac{1}{C_{K,1EF}} = \frac{\text{No. C in series without a fault}}{\text{No. C in parallel} \cdot C_E} + \frac{1}{(\text{No. C in parallel} - 1) \cdot C_E}$$

$$\frac{1}{C_{K,1EF}} = \frac{6}{14 \cdot C_E} + \frac{1}{13 \cdot C_E} = \frac{1}{0.051397\ \mu F}$$

$C_{K,1EF}$ = 19.456 μF

2f) Capacitance in the Quarter of the H Connection during an Element Fault

Consider 2 special conditions:

- Cross-linking and therefore the parallel connection of 2 cans, refer to Figure 7-11
- Current transformer is not in the center of the levels

Therefore, the following calculation must be performed for the upper (C1) and lower quarter (C3).

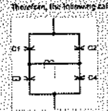

Figure 7-13 Quarters of the Capacitor Bank

Based on the cross-linking of the cans, in case of an element fault, the capacitance of the parallel cans must be determined first:

- Capacitance of 2 parallel cans in case of an element fault:

$C_{2K,1EF}$ = 19.456 μF + 19.67 μF = 39.126 μF

Capacitance in the quarter of C1 in case of an element fault:

$$\frac{1}{C1_{1EF}} = \frac{\text{No. cans in series without a fault}}{2 \cdot C_K} + \frac{1}{C_{2K,1EF}}$$

$$\frac{1}{C1_{1EF}} = \frac{12}{2 \cdot 19.67\ \mu F} + \frac{1}{39.126\ \mu F} = \frac{1}{0.3306\ \mu F}$$

$C1_{1EF}$ = 3.0249 μF

- Capacitance in the quarter of C3 in case of an element fault:

$$\frac{1}{C3_{1EF}} = \frac{14}{2 \cdot 19.67\ \mu F} + \frac{1}{39.126\ \mu F} = \frac{1}{0.3814\ \mu F}$$

$C3_{1EF}$ = 2.6217 μF

2g) Capacitance in the Quarters of the H Connection without Element Fault

- Capacitance in the quarters of C1 and C3 without element fault:

$$C1 = \frac{2 \cdot C_K}{\text{No. cans in series}} = \frac{2 \cdot 19.67\ \mu F}{13} = 3.026\ \mu F$$

$$C3 = \frac{2 \cdot C_K}{\text{No. cans in series}} = \frac{2 \cdot 19.67\ \mu F}{15} = 2.623\ \mu F$$

2h) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault

- Unbalanced current:

$$I_{unb} = I_c \left| \frac{C1}{(C1 + C2)} - \frac{C3}{(C3 + C4)} \right|$$

- Unbalanced current in case of an element fault in C1:

$$I_{unb} = 219.9\ A \left| \frac{3.0249\ \mu F}{(3.0249\ \mu F + 3.026\ \mu F)} - \frac{2.623\ \mu F}{(2.623\ \mu F + 2.623\ \mu F)} \right| = 20.0\ mA$$

- Unbalanced current in case of an element fault in C3:

$$I_{unb} = 219.9\ A \left| \frac{3.026\ \mu F}{(3.026\ \mu F + 3.026\ \mu F)} - \frac{2.6217\ \mu F}{(2.6217\ \mu F + 2.623\ \mu F)} \right| = 27.3\ mA$$

The lesser of both values is relevant for the setting of the threshold value. For instance, set the threshold to 75 % of this value:

- Threshold value (primary): 0.75 · 20.0 mA = 15.0 mA

The threshold is a primary value. In order to detect this, a 1:1 transformer is required. Under this assumption, the secondary setting value is equal to the primary value.

NOTE

Use sensitive device current inputs in order to apply secondary thresholds of < 30 mA.

Example 3 (a to d): Unbalanced-Current Information Not Available from the Manufacturer of the Capacitor Bank, External Capacitor-Bank Structure without Cross-Linked Cans

Example 3 is almost identical to example 2. The only difference is that the cans are not cross-linked. Here, only the calculation part is discussed that is a result of the different external structure. Information for additional calculations can be found in example 2.

3a) External Structure of the Capacitor Bank

The external structure of the capacitor bank must be known or must be determined. This information can be requested from the manufacturer of the capacitor bank.

This example assumes the following external structure of the capacitor bank:
- 28 levels (cans) in series
- 4 cans per level
- H transformer between levels 13 and 14, counting from top to bottom
- Parallel cans are not cross-linked, refer to the following diagram

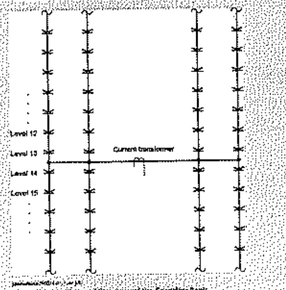

Figure 7-14 External Structure of the Capacitor Bank

3b) Capacitance in the Quarter of the H Connection during an Element Fault

The current transformer is not located in the center of the levels; therefore, the following calculation for the upper (C1) and the lower quarter (C3) must be performed.

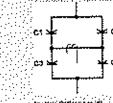

Figure 7-15 Quarters of the Capacitor Bank

EXAMPLE

- Add a Marker command (SPC signal) to the Information list.

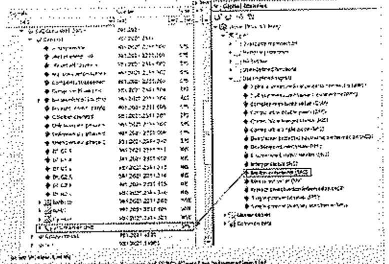

Figure 7-16 Adding Marker Command (SPC) Signal to Information List

- Set up the following CFC. Connect the SPC signal as input, and the signal >Reset all counters as output.

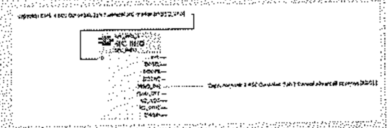

Figure 7-17 Function Chart (CFC): Activating the Binary Input Signal

- Send a single-point control command from the control center to the SPC signal to activate the signal >Reset all counters. Then the counters are reset.

7.4.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MP selection				
_:13501:100	MP selection:Consistency failure		• no MP configured • no Sensor configured	no MP configured

- Capacitance in the quarter of C1 in case of an element fault ($C1_{EF}$):

Capacitance in the row without element fault:

$$\frac{1}{C1_{RnEF}} = \frac{\text{No. cans in series}}{C_K} = \frac{13}{19.67\,\mu F}$$

$C1_{eq1} = 1.5130\ \mu F$

- Capacitance in the row with element fault:

$$\frac{1}{C1_{RmEF}} = \frac{\text{No. cans in series without a fault}}{C_K} + \frac{1}{C_{1,EF}} = \frac{12}{19.67\,\mu F} + \frac{1}{19.456\,\mu F}$$

$C1_{eq2} = 1.5118\ \mu F$

$C1_{EF} = C1_{eq1} + C1_{eq2} = 1.5130\ \mu F + 1.5118\ \mu F = 2.0248\ \mu F$

- Capacitance in the quarter of C3 in case of an element fault ($C3_{EF}$):

Capacitance in the row without element fault:

$$\frac{1}{C3_{RnEF}} = \frac{\text{No. cans in series}}{C_K} = \frac{15}{19.57\,\mu F}$$

$C3_{eq1} = 1.3113\ \mu F$

- Capacitance in the row with element fault:

$$\frac{1}{C3_{RmEF}} = \frac{\text{No. cans in series without a fault}}{C_K} + \frac{1}{C_{K,EF}} = \frac{14}{19.67\,\mu F} + \frac{1}{19.456\,\mu F}$$

$C3_{eq2} = 1.3104\ \mu F$

$C3_{EF} = C3_{eq1} + C3_{eq2} = 1.3113\ \mu F + 1.3104\ \mu F = 2.6217\ \mu F$

3c) Capacitance in the Quarters of the H Connection without Element Fault

The values are identical to those values in the example 2g) Capacitance in the Quarters of the H Connection without Element Fault, Page 935.

3d) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault

Use the values determined under 3b) for those formula listed in example 2h) Unbalanced Current and Threshold-Value Setting in Case of a C-Element Fault, Page 933.

Resetting the Counters via Protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus

The following example shows how to use a function chart (CFC) to reset the counters with the protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus.

Addr.	Parameter	C	Setting Options	Default Setting
_:13501:81	MP selection:MP selection		Setting options depend on configuration	
General				
_:2311:101	General:Automatic compensation		• no • yes	no
_:2311:100	General:Normalization with Ic		• no • yes	no
_:2311:102	General:Thresh. defect. C-elem.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:2311:104	General:De-energ. time w/o comp.		0.00 s to 60.00 s	2.00 s

7.4.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
General			
_:2311:500	General:>Compensate	SPS	I
_:2311:501	General:>Reset comp. val.	SPS	I
_:2311:502	General:>Reset all counters	SPS	I
_:2311:302	General:Alg. not compensated	SPS	O
_:2311:303	General:Compens. succeeded	SPS	O
_:2311:304	General:Comp. via BI blk.(Ic>)	SPS	O
_:2311:305	General:I>-stage(trip) blk.(Ic<)	ACT	O
_:2311:306	General:No auto. comp. config.	SPS	O
_:2311:307	General:C defect counted	SPS	O
_:2311:308	General:Unknown dir. phase A	SPS	O
_:2311:309	General:Unknown dir. phase B	SPS	O
_:2311:310	General:Unknown dir. phase C	SPS	O
_:2311:311	General:Df. G1 A	INS	O
_:2311:312	General:Df. G1 B	INS	O
_:2311:313	General:Df. G1 C	INS	O
_:2311:314	General:Df. G2 A	INS	O
_:2311:315	General:Df. G2 B	INS	O
_:2311:316	General:Df. G2 C	INS	O
_:2311:300	General:Iunbl.cp	WYE	O
_:2311:301	General:Iunbl.	WYE	O
_:2311:323	General:Cp.vect	WYE	O

7.4.4 Overcurrent-Protection Stage I>

7.4.4.1 Description

Logic of a Stage

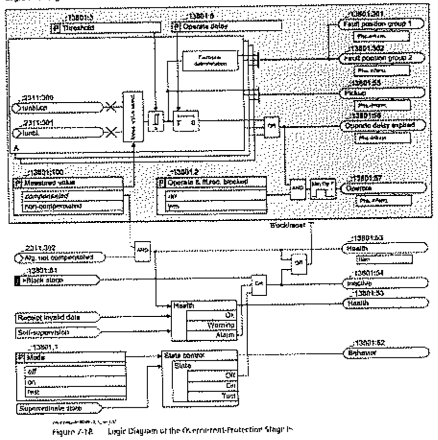

Figure 7-18 Logic Diagram of the Overcurrent-Protection Stage I>

Measurands

Within the protection stage, the compensated and the non-compensated unbalanced currents are available. Use the parameter Measured value to select one of the 2 values. Both values are displayed as measured values of the function at the function stage.

Pickup, Tripping Delay

If the selected measurand in one of the phase measuring element exceeds the threshold, the stage picks up. The pickup starts a tripping time delay, and a fault-location information is issued. More information can be found in this chapter under Fault-Location Information, Page 941. If the threshold is exceeded during the entire tripping delay, a phase-selective operate indication is issued.

Please note that, when using the compensated measurands as well as the automatic compensation, the currently measured current unbalance (that resulted in the threshold being exceeded) is gradually compensated. This means that even in case of a constantly existing unbalance in the primary system, the compensated measurand becomes gradually lower and may therefore fall below the threshold again at some time. The timing depends on by how much the threshold is exceeded.

For this reason and under these conditions, long time delays must not be set, see also chapter 7.4.4.2 Application and Setting Notes.

This effect does not occur if manual compensation or the non-compensated measurand is used.

Blocking While Charging

In order to prevent pickup as a consequence of the charging process, the I> stage is implicitly blocked in a phase-selective way for 250 ms by setting $I_{unbl.,comp.}$ to 0 A, after capacitor energizing has been detected. Blocking only takes place if the stage operates with compensated unbalanced values.

Fault-Location Information

When picking up, the stage provides information about the faulty group of the capacitor bank. If the location can be safely determined, the corresponding indication Fault position group 1 or Fault position group 2 is issued.

Both indications also contain the information about the faulty phase. If the capacitor is implemented as an H connection, the following definition is assumed:

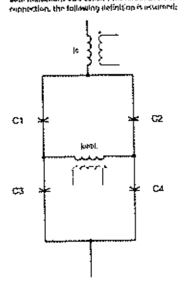

Figure 7-19 Definition for the Fault Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1 and C4
- Group 2: C3 and C2

In order to determine the fault location (group 1 or 2) correctly, use the parameter Capacitor element type (in FB General of the Capacitor bank function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

Non-Compensated Status

If no compensated values are available and the stage has been set to use such values, the stage will be blocked. The readiness of the stage turns to Warning. This condition will be reported on the function stage (indication Alg. not compensated).

7.4.4.2 Application and Setting Notes

Parameter: Measured value

- Default setting (_:13801:100) Measured value = no

With the parameter, you set the Measured value.

Parameter Value	Description
compensated	The stage uses compensated unbalanced values. This means an operational current unbalance will be eliminated. This allows you to significantly increase the sensitivity of the measurement. Note the following: If the current I_c is lower than the threshold Current threshold CB open, the affected phase measuring elements are rendered inactive by setting $I_{unbl.,comp.}$ to 0 A. This condition is held for 250 ms after energizing has been detected in order to avoid a pickup as a consequence of the charging process. Siemens recommends using compensated unbalanced values. In case that automatic compensation is applied, please consider the setting notes for the operate delay.
non-compensated	The stage works with non-compensated unbalanced values. This means the measurand may contain an existing operational current unbalance.

Parameter: Threshold

- Default setting (_:13801:3) Threshold = 0.2 A

Set the parameter Threshold for the specific application.

When using compensated unbalanced values, very sensitive settings are possible. When using non-compensated unbalanced values, the threshold must be higher than the maximum operational unbalanced current.

Parameter: Operate delay

- Default setting (_:13801:6) Operate delay = 0.04 s (for the 1st stage)

Set the parameter Operate delay for the specific application.

> **NOTE**
>
> If the function has been set to automatic compensation and the stage works with compensated values, the maximum permitted operate delay is 80 ms. If the operate delay is set to longer than 80 ms, the automatic compensation might cause dropout of the picked-up stage. This risk does not exist when manual compensation or non-compensated values are used.

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7.4.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I> 1				
_:13801:1	I> 1:Mode		• off • on • test	off
_:13801:2	I> 1:Operate & flt.rec. blocked		• no • yes	no
_:13801:100	I> 1:Measured value		• compensated • non compensated	compensated
_:13801:3	I> 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.000 A
_:13801:6	I> 1:Operate delay		0.00 s to 60.00 s	0.08 s

7.4.4.4 Information List

No.	Information	Data Class (Type)	Type
I> 1			
_:13801:81	I> 1:>Block stage	SPS	I
_:13801:54	I> 1:Inactive	SPS	O
_:13801:52	I> 1:Behavior	ENS	O
_:13801:53	I> 1:Health	ENS	O
_:13801:55	I> 1:Pickup	ACD	O
_:13801:56	I> 1:Operate delay expired	ACT	O
_:13801:57	I> 1:Operate	ACT	O
_:13801:301	I> 1:Fault position group 1	ACT	O
_:13801:302	I> 1:Fault position group 2	ACT	O
I> 2			
_:13802:81	I> 2:>Block stage	SPS	I
_:13802:54	I> 2:Inactive	SPS	O
_:13802:52	I> 2:Behavior	ENS	O
_:13802:53	I> 2:Health	ENS	O
_:13802:60	I> 2:Inrush blocks operate	ACT	O
_:13802:55	I> 2:Pickup	ACD	O
_:13802:56	I> 2:Operate delay expired	ACT	O
_:13802:57	I> 2:Operate	ACT	O
_:13802:301	I> 2:Fault position group 1	ACT	O
_:13802:302	I> 2:Fault position group 2	ACT	O

7.4.5 Counter Stage

7.4.5.1 Description

Logic of a Stage

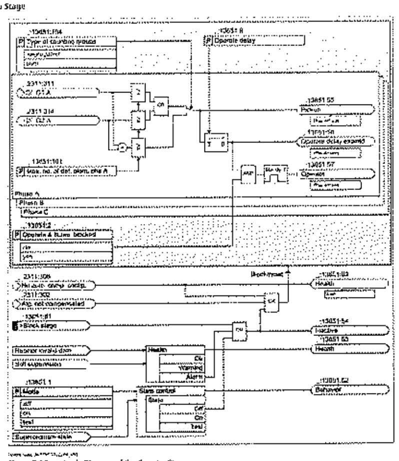

Figure 7-20 Logic Diagram of the Counter Stage

Measured/Input Values

The measured/input values of the counter stage are the phase- and group-segregated counter contents that are determined in the General FB.

Pickup, Tripping Delay

Supervision of the counter contents is phase-segregated. If a counter reaches the current thresholds (parameter Max. no. of def. elem. phs A, Max. no. of def. elem. phs B, Max. no. of def. elem. phs C), the stage picks up. When using the parameter Type of counting groups, a selection is made whether the supervision function occurs group-segregated or with the sum value of both groups. The pickup starts the time delay. If the time delay has elapsed, the operate indication will be issued.

Automatic Compensation

If the automatic compensation function is enabled, the counter stage is working. If this is not the case, the readiness status of the stage changes to the state Warning.

7.4.5.2 Application and Setting Notes

General Notes

- The setting notes for the current-threshold value for counting faulty C-elements are provided in chapter 7.4.3.2 Application and Setting Notes as you must set this parameter across all stages.
- In order to react quickly to the simultaneous fault of many C-elements, always use an overcurrent protection stage I> with a short tripping delay (< 100 ms) in addition to the counter stage. This is necessary, as the counter function counts each current jump only once, regardless of its height.

Parameter: Type of counting groups

- Default setting (_:13651:104) Type of counting groups = segregated

When using the parameter Type of counting groups, you specify whether the group-segregated counter status or the sum of both group counters are compared to the threshold.

Parameter: Maximum Number of Faulty Elements, Operate delay

- Default setting (_:13651:101) Max. no. of def. elem. phs A = 10
- Default setting (_:13651:102) Max. no. of def. elem. phs B = 10
- Default setting (_:13651:103) Max. no. of def. elem. phs C = 10
- Default setting (_:13651:6) Operate delay = 0.00 s

Set the parameters for the specific application.

It is possible to configure several stages for different tasks:

- Reporting only (with or without fault record)
  Use this stage to report 1 or 2 faulty C-elements. To do this, set the 3 parameters Max. no. of def. elem. phs A, Max. no. of def. elem. phs B and Max. no. of def. elem. phs C to a small value (1 or 2). The parameter Operate delay can be set to 0.
  If you would like to prevent the operate (tripping) and fault logging (fault log and fault record), set the parameter Operate & flt.rec. blocked to yes.
  If you would like to prevent only the operate (tripping) and the fault logging must occur, remove this stage from the interface Trip to the circuit breaker (see also 5.4.2 Structure of the Function Group, Interfaces with Circuit-Breaker Function Group).
- Indication with delayed operate
  Use this stage to report in case of some faulty C-elements and set a relatively long time delay of the operate, for example, 2 hours. During this time, the fault of the C-elements can be clarified. If it is possible to find a solution, the counter status can be reset manually. This way, the stage drops out. If a solution cannot be found within 2 hours, the stage trips and disconnects the capacitor bank.
- Immediate operate
  The stage is used to initiate the operate immediately after a larger number of C-elements become faulty.

7.4.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Counter 1				
_:13651:1	Counter 1:Mode		• off • on • test	off
_:13651:2	Counter 1:Operate & flt.rec. blocked		• no • yes	no
_:13651:104	Counter 1:Type of counting groups		• segregated • sum	segregated
_:13651:101	Counter 1:Max. no. of def. elem. phs A		1 to 1000	10
_:13651:102	Counter 1:Max. no. of def. elem. phs B		1 to 1000	10
_:13651:103	Counter 1:Max. no. of def. elem. phs C		1 to 1000	10
_:13651:6	Counter 1:Operate delay		0.00 s to 10000.00 s	0.00 s

7.4.5.4 Information List

No.	Information	Data Class (Type)	Type
Counter 1			
_:13651:81	Counter 1:>Block stage	SPS	I
_:13651:54	Counter 1:Inactive	SPS	O
_:13651:52	Counter 1:Behavior	ENS	O
_:13651:53	Counter 1:Health	ENS	O
_:13651:55	Counter 1:Pickup	ACD	O
_:13651:56	Counter 1:Operate delay expired	ACT	O
_:13651:57	Counter 1:Operate	ACT	O

7.5 Current-Unbalance Protection for Capacitors, 1-Phase

7.5.1 Overview of Functions

The Current-unbalance protection for capacitors, 1-phase function (ANSI 60C):

- Protects in case of faults in capacitor elements (C-elements) of a double neutral point capacitor bank
- Provides very sensitive supervision of the unbalanced current between the 2 neutral points
- Allows counting individual faulty C-elements

7.5.2 Structure of the Function

The Current-unbalance protection for capacitors, 1-phase function is used in the Capacitor bank function group. It is preconfigured at the factory with 2 overcurrent-protection stages I> and 1 stage of the type Counter. A maximum of 3 overcurrent-protection stages and 4 counter stages can be operated simultaneously in the function.

The function is designed so that the General functionality (including adjustment) and the Measuring-point selection can work across the stages.

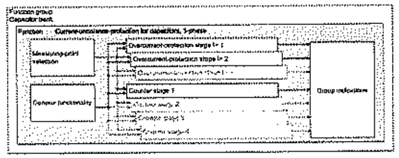

Figure 7-21 Structure/Embedding of the Function

7.5.3 General Functions and Measuring-Point Selection

7.5.3.1 Description

The General functionality is structured in the following functional parts.

- Compensation of the unbalance
- Normalization of the unbalanced current with the current I_c
- Counting faulty C-elements (the stage type Counter is used to monitor the counter status)

Logic for Compensation and Normalization

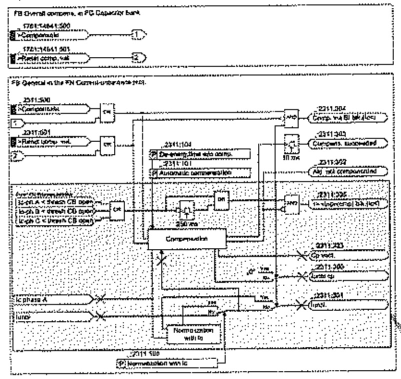

Figure 7-22 Cross-Stage Functionality

Measuring-Point Selection

With the MP selection parameter, you can select from a list of measuring points a 1-phase measuring point that is connected to the I Unbalanced interface in the Capacitor bank function group. The Current-unbalance protection for capacitors, 1-phase function processes the 1-phase current that is connected to the measuring point.

For more information, refer to the description of the Capacitor bank function group starting from chapter 5.4.1 Overview.

Measurands, Method of Measurement

The function receives its measurands via the I Unbalanced interface of the Capacitor bank function group. The compensated and non-compensated unbalanced currents are provided for the overcurrent protection stage. Within the protection stage, one of the 2 values is selected in the protection stage via the parameter Measured value. Both values are available as functional measured values (see Figure 7-22).

Configure across the stages whether the unbalanced current must be normalized with the current I_c that flows into the capacitor bank. Phase A component of the current I_c flowing into the capacitor bank is used as the reference for the normalization. You can find more information in this chapter under Normalization with I_c, Page 950.

The method of measurement used processes the sampled unbalanced current values and filters out the fundamental components numerically. The protection stages evaluate the fundamental component of the unbalanced current.

General Notes on the Compensation

An operational unbalanced current is added to an unbalanced current resulting from faulty capacitor elements. This corrupts the measuring result.

Operational unbalanced currents can result from the following causes:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates operational unbalanced currents by calculation. For this purpose, the phasor of the operational unbalanced current $I_{unbal,op}$ is stored at specific times. The stored phasor (compensation phasor), is subtracted from the actually measured unbalanced-current phasor:

$$I_{unbal,comp} = I_{unbal} - I_{unbal,op}$$

The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. The compensated values are not available under the following conditions: • After initial startup of the device before any compensation is carried out • After activating the binary input >Reset comp. val. • After change of $I_{unbal,op}$. Protection stages that are working with compensated values are inactive.
Compens. succeeded	This indication is issued (as transient indication with a pulse duration of 10 ms) if the existing unbalance has been compensated manually or automatically. In case of automatic compensation, the signal is issued at each event-based situation where full compensation is carried out.
Comp. via BI blk. (Tc<)	If a manual compensation has been initiated and the current I_c (current flowing into the capacitor bank) at this time is less than the threshold Current thresh. CB open, the manual compensation is not executed. This is signaled via the Comp. via BI blk. (Tc<) indication.

2 different methods are available for the compensation:

- Manual compensation via binary input signals
- Automatic compensation

Manual Compensation via Binary Input Signal

If the binary input signal >Compensate is activated, the manual compensation starts. This will fully compensate any unbalance that exists at this time. This means, the value $I_{unbal,comp}$ will then become 0. You can also use the manual compensation in parallel with the automatic compensation.

Automatic Compensation

When using the parameter Automatic compensation, this automatic compensation function can be enabled or disabled.

The automatic compensation consists of 2 different mechanisms:

- Event-based compensation of any existing unbalance
  This compensation is performed in the following situations:
  - After energizing the capacitor bank or a phase of the bank
  - After counting a faulty C-element
  - After each startup of the device
  - After specific parameter changes:
    - Switching on the automatic compensation
    - Changing the rated current of the capacitor bank

  In order to avoid transient inrush-current effects, the compensation is delayed by 250 ms after energizing has been detected.
  Full compensation after bank energization can be avoided in case of very short de-energization by means of parameter De-energ. time w/o comp.. If the de-energized duration is less than the setting of parameter De-energ. time w/o comp., the full compensation is not carried out after energizing a phase or the whole bank.
- Cyclic, slow and thus gradual compensation of an existing unbalance in small increments
  This permits, for example, the automatic compensation of environmental influences.

Resetting the Compensation

The algorithm can be reset to the non-compensated status. Compensated values are not available in this case. Protection stages that work with compensated values are rendered inactive. The binary input signal >Reset comp. val. of the function or function group resets the compensation (see also Figure 7-22).

Normalization with I_c

The threshold for the unbalanced current is usually set by assuming the rated capacitor current $I_{c,rated}$. The current I_c flowing into the capacitor bank determines the amount of the unbalanced current. A lower I_c also means a lower unbalanced current. If $I_c < I_{c,rated}$, the protection becomes less sensitive. This imbalance can be compensated via the normalization. Normalization keeps the sensitivity of the protection function constant by normalizing the unbalance value with the current I_c. Phase A component of the current I_c flowing into the capacitor bank is used as the reference for the normalization. When using the parameter Normalization with Ic, normalization is enabled or disabled.

I_c Lower than Current Thresh. CB Open

If any phase current of I_c is lower than the threshold Current thresh. CB open, the compensated value can no longer be computed with sufficient accuracy. To avoid a malfunction, the compensated unbalanced value $I_{unbal,comp}$ is set to 0 A (see Figure 7-22). This deactivates the protection stages that work with compensated values.

This condition will be indicated (indication Ic<stage(comp) blk.(Tc<)).

In this case, normalization with current I_c will no longer work properly either. Normalization is canceled. This means that the non-normalized value will be used instead of the normalized value (see Figure 7-22).

Charging/Energizing the Capacitor Bank or a Phase of the Bank

Charging of the bank takes place when the discharged bank is switched on to the network. Charging of a phase can occur in case of network faults. If a phase-to-ground voltage drops to 0 V due to a network fault, the respective phase is discharged and the return of the phase-to-ground voltage (after the fault has been cleared) will charge the phase.

Charging the bank causes inrush currents in the respective phases. To avoid overfunction in case of sensitive threshold settings, the stages using compensated unbalanced values are blocked by setting $I_{unbal,comp}$ to 0 A.

These stages are:

- Counter stage
- I> stage, if set to operate with compensated unbalanced values

The blocking ($I_{unbal,comp}$ set to 0 A) lasts for 250 ms after energizing detection. Afterwards, the calculated $I_{unbal,comp}$ is processed again.

Energizing detection takes place by monitoring the phase currents I_c flowing into the bank. If all three phase currents exceed the threshold Current Thresh. CB Open, energizing is detected.

Logic for Counting Faulty C-Elements

This part of the General functionality is only important if counter stages are used.

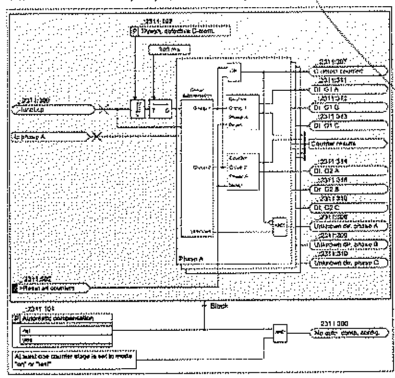

Figure 7-23 Counting Faulty C-Elements

Activation/Blocking Counting

If at least one counter stage is enabled, the counting function is active. Furthermore, the counting function works only if the automatic compensation is enabled.

In order to prevent counting as a consequence of the charging process, the counter function is implicitly blocked for 250 ms by setting $I_{unbal,comp}$ to 0 A, after the capacitor energizing has been detected.

Measurands, Counting

The measurand is the 1-phase compensated unbalanced current $I_{unbal,comp}$. If a single C-element is faulty, an unbalance occurs between the neutral points of the 2 capacitor banks. This unbalance causes an unbalanced current; this means, a small current jump occurs in the unbalanced current. Set the parameter Thresh. defective C-elem., so that this current jump can be detected (see also 7.5.3.2 Application and Setting Notes). The unbalanced current that was caused by the fault must exceed the threshold for 100 ms before the affected phase and the affected group are determined and counting (incrementing the counter) takes place. The angle reference of the unbalanced-current phasor to the reference current I_c is used to determine the phase of the faulty C-element. Thus, phase-segregated counting is possible. There is one counter for each phase and group. After the counting, the existing unbalance is compensated; this means, the unbalance is reset to 0 A. If the faulty group cannot be determined, the unbalance is also compensated.

Resetting/Setting the Counters

You can reset or set the counters of group 1 and group 2 via:

- On-site operation panel directly on the device
- Online DIGSI connection to the device
- Binary input >Reset all counters (only reset of all counters)
- Communication connection with the control center

You can directly set or reset the counters via IEC 61850 by setting the counter values to the desired value. If you want to reset the counters via DNP3, IEC 60870-5-103, Modbus, or IEC 60870-5-104, an additional configuration with CFC is necessary. For more information, refer to chapter 7.5.3.2 Application and Setting Notes.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:300) Iunbl.cp	Compensated unbalanced current $I_{unbal,comp}$	kA	A	Parameter Rated primary current
(_:2311:301) Iunbl.	Non-compensated unbalanced current I_{unbal}	kA	A	Parameter Rated primary current
(_:2311:323) Cp.vect.	Compensation vector $I_{unbal,op}$	kA	A	Parameter Rated primary current

You can find the value of the parameter Rated primary current in the preceding table in the chapter 6.3.6 Settings according to the specified parameter MP selection.

$I_{comp,vect}$ is normalized with I_c. The normalization is carried out no matter if the parameter Normalization with Ic is set to yes or no. $I_{comp,vect}$ keeps its value unchanged until the next compensation occurs.

$$I_{comp,vect} = I_{unbal,op} \cdot \frac{I_{c,rated}}{I_c}$$

Where:

$I_{unbal,op}$	Operational unbalanced current at the moment the compensation is carried out
$I_{c,rated}$	Rated current of the capacitor bank
I_c	Current of the capacitor bank at the moment the compensation is carried out

Definition of the Group and Fault Location in Case of a Capacitor Dual Switching

If the capacitor is designed with dual switching function, the following definition is assumed:

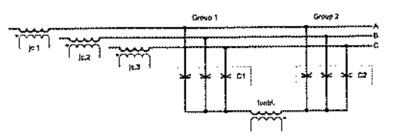

Figure 7-24 Definition of the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1
- Group 2: C2

In order to determine the fault location (group 1 or 2) correctly, use the parameter Capacitor element type (in FB General of the Capacitor bank function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

The angle reference of the unbalanced current phasor to the reference current I_c is used to determine the direction of the unbalanced current and, thus, the affected group is determined. If the direction cannot be determined with confidence, an appropriate indication will be generated.

7.5.3.2 Application and Setting Notes

Parameter: MP selection

- Default setting (_:13501:81) MP selection = None

With the MP selection parameter, you can select from a list the measuring point that is connected to the I Unbalanced interface of the Capacitor bank function group.

The setting applies equally to all stages of the function.

In the default setting, a measuring point is not selected. You must select a measuring point. If you do not select a measuring point, an inconsistency is indicated via the read-only parameter Consistency failure.

Parameter: Automatic compensation

- Default setting (_:2311:101) Automatic compensation = no

The parameter applies equally to all stages of the function that work with compensated measurands.

If no counter stages are applied, Siemens recommends to switch the automatic compensation off and use the manual compensation. You can find more information on this recommendation in chapter 7.5.4.2 Application and Setting Notes (setting notes for the operate delay of the I> stage).

If the counter stages are applied, the automatic compensation must be switched on, otherwise the counting function will not work.

Parameter: De-energ. time w/o comp.

- Default setting (_:2311:104) De-energ. time w/o comp. = 3.00 s

In case of network faults, the faulty phases are discharged. With the returning voltage after fault clearance, charging takes place. For such conditions, Siemens recommends that no automatic full compensation takes place in the affected phases. Otherwise, C-element defects occurring in this period (for example, because of discharging stress due to network-fault inception) will not be detected.

With the parameter De-energ. time w/o comp., you define the duration of short de-energization after which no automatic compensation takes place. The parameter must be set to a value larger than the slowest fault clearing time in your network plus a safety margin.

If the setting is set to 0 s, an automatic full compensation is carried out after each energizing detection.

Parameter: Normalization with Ic

- Default setting (_:2311:100) Normalization with Ic = no

This parameter applies equally to all stages of the function.

Parameter Value	Description
no	Select this setting if you can safely assume that I_c will not change for operational reasons or if you do not desire normalization of the unbalanced current with I_c. Please consider that the protection sensitivity will decrease with decreasing I_c.
yes	Select this setting if you want to keep the sensitivity of the protection stages constant during changes of I_c.

Parameter: Thresh. defective C-elem.

- Default setting (_:2311:102) Thresh. defective C-elem. = 0.020 A

Set the parameter Thresh. defective C-elem. to ensure that the jump in the unbalanced current caused by the faulty C-element is detected. Information about occurring unbalanced current as a consequence of single faulty C-elements will be provided by the manufacturer of the capacitor bank. Siemens recommends to set the threshold value to approx. 75 % of the unbalanced current that occurs after the fault of the 1st C-element.

Example 1: Information about the Unbalanced Current Available from the Manufacturer of the Capacitor Bank

Table 7-2 Unbalanced Current, Depending on the Number of Faulty C-Elements

Number of Faulty C-Elements	Primary Unbalanced Current
0	0.00 A
1	0.71 A
2	1.47 A
3	2.29 A
...	...

Assumed current transformer ratio: 10 A/1 A

Primary unbalanced current if 1st C-element fails: 0.71 A

Secondary unbalanced current if 1st C-element fails: 0.071 A

Secondary setting value: 0.75 · 0.071 A = 0.053 A

> **NOTE**
> Use sensitive device current inputs in order to apply secondary thresholds at < 40 mA.

Resetting the Counters via Protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus

The following example shows how to use a function chart (CFC) to reset the counters with the protocols IEC 60870-5-103, IEC 60870-5-104, DNP3, or Modbus.

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EXAMPLE

- Add a Marker command (SPC) signal to the Information List.

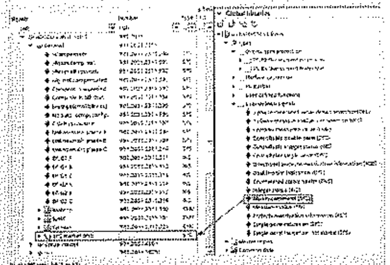

Figure 7-25 Adding Marker Command (SPC) Signal to Information List

- Set up the following CFC. Connect the SPC signal as input, and the signal >Reset all counters as output.

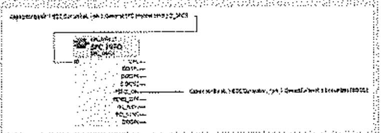

Figure 7-26 Function Chart (CFC): Activating the Binary Input Signal

- Send a single-point control command from the control center to the SPC signal to activate the signal >Reset all counters. Then the counters are reset.

7.5.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
MP selection				
_:13501:106	MP selectionConsistency failure		• no MP configured • no Sensor configured	no MP configured

Addr.	Parameter	C	Setting Options	Default Setting
_:13501:81	MP selection:MP selection		Setting options depend on configuration	
General				
_:2311:101	General:Automatic compensation		• no • yes	no
_:2311:100	General:Normalization with Ic		• no • yes	no
_:2311:102	General:Thresh. defective C-elem.	1 A @ 100 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 100 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.030 A
		5 A @ 50 Irated	0.15 A to 175.00 A	0.15 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.030 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.150 A
_:2311:104	General:De-ening time auto comp.		0.00 s to 60.00 s	2.00 s

7.5.3.4 Information List

No.	Information	Data Class (Type)	Type
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
General			
_:2311:500	General:>Compensate	SPS	I
_:2311:501	General:>Reset comp. val.	SPS	I
_:2311:502	General:>Reset all counters	SPS	I
_:2311:302	General:Alg. not compensated	SPS	O
_:2311:303	General:Compens. succeeded	SPS	O
_:2311:304	General:Comp. via BI blk. (Ic<)	SPS	O
_:2311:305	General:I~-stage(cmp) blk.(Ic<)	SPS	O
_:2311:306	General:No auto. comp. config.	SPS	O
_:2311:307	General:C defect counted	SPS	O
_:2311:308	General:Unknown dir. phase A	SPS	O
_:2311:309	General:Unknown dir. phase B	SPS	O
_:2311:310	General:Unknown dir. phase C	SPS	O
_:2311:311	General:DL G1 A	INS	O
_:2311:312	General:DL G1 B	INS	O
_:2311:313	General:DL G1 C	INS	O
_:2311:314	General:DL G2 A	INS	O
_:2311:315	General:DL G2 B	INS	O
_:2311:316	General:DL G2 C	INS	O
_:2311:300	General:Iunbl.cp	CMV	O
_:2311:301	General:Iunbl.	CMV	O
_:2311:323	General:Cp.vect.	CMV	O

7.5.4 Overcurrent-Protection Stage I>

7.5.4.1 Description

Logic of a Stage

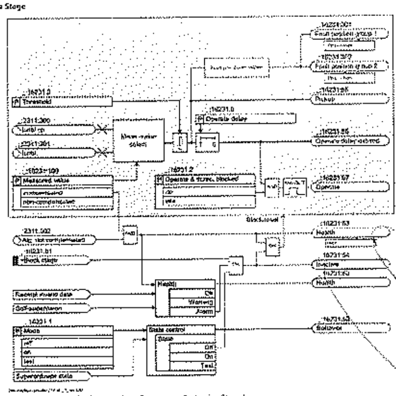

Figure 7-27 Logic Diagram of the Overcurrent-Protection Stage I>

Measurands

Within the protection stage, the compensated and the non-compensated unbalanced currents are available. Use parameter Measured value to select one of the 2 values. Both values are displayed as measured values of the function at the function stage.

Pickup, Operate Delay

If the selected measurand exceeds the threshold, the stage picks up. The pickup starts the operate delay, and a fault-location information is issued. More information can be found in this chapter under Fault-Location Information, Page 958. If the threshold is exceeded during the entire operate delay, the operate indication is issued.

Please note that, when using the compensated measurands as well as the automatic compensation, the currently measured current unbalance (that resulted in the threshold being exceeded) is gradually compensated. This means that even in case of a constantly existing unbalance in the primary system, the compensated measurand becomes gradually lower and may therefore fall below the threshold again at some time. The timing depends on by how much the threshold is exceeded.

For this reason and under these conditions, long time delays must not be set, see also chapter 7.5.4.2 Application and Setting Notes.

This effect does not occur if manual compensation or the non compensated measurand is used.

Blocking While Charging

In order to prevent pickup as a consequence of the charging process, the I> stage is implicitly blocked for 250 ms by setting $I_{unbal,comp}$ to 0 A, after capacitor energizing has been detected. Blocking only takes place if the stage operates with compensated unbalanced values.

Fault-Location Information

When picking up, the stage provides information about the faulty group of the capacitor bank. If the location can be safely determined, the corresponding indication Fault position group 1 or Fault position group 2 is issued.

Both indications also contain the information about the faulty phase. If the capacitor is implemented with 2 neutral points, the following definition is assumed:

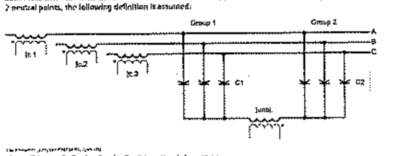

Figure 7-28 Definition for the Fault-Location Information

The black dot indicates the orientation of the current transformer. For the connection of the current transformer shown in the previous figure, the following definition applies:

- Group 1: C1
- Group 2: C2

In order to determine the fault location (group 1 or 2) correctly, use the parameter Capacitor element type (in FB General of the Capacitor bank function group) to tell the device whether the elements of the capacitor bank have internal fuses or not.

Non-Compensated Status

If no compensated values are available and the stage has been set to use such values, the stage will be blocked. The readiness of the stage turns to warning. This condition will be reported on the function stage (indication Alg. not compensated).

7.5.4.2 Application and Setting Notes

Parameter: Measured value

- Default setting (_:16231:100) Measured value = compensated

With this parameter you set the Measured value.

Parameter Value	Description
compensated	The stage uses compensated unbalanced values. This means an operational current unbalance will be eliminated. This allows you to increase significantly the sensitivity of the measurement. Note: If any phase current I_x is lower than the threshold Current threshold CB open, the stage is rendered inactive by setting $I_{unbal,comp}$ to 0 A. This condition is held for 250 ms after energizing has been detected in order to avoid a pickup as a consequence of the charging process. Siemens recommends using compensated unbalanced values. In case that automatic compensation is applied, consider the setting notes for the operate delay.
non-compensated	The stage works with non-compensated unbalanced values. This means the measurand may contain an existing operational current unbalance.

Parameter: Threshold

- Default setting (_:16231:3) Threshold = 1.500 A

Set the parameter Threshold for the specific application.

When using compensated unbalanced values, very sensitive settings are possible. When using non-compensated unbalanced values, the threshold must be higher than the maximum operational unbalanced current.

Parameter: Operate delay

- Default setting (_:16231:6) Operate delay = 0.30 s (for the 1st stage)

Set the parameter Operate delay for the specific application.

> **NOTE**
>
> If the function has been set to automatic compensation and the stage works with compensated values, the maximum permitted operate delay is 80 ms. If the operate delay is set to longer than 80 ms the automatic compensation might cause dropout of the picked-up stage. This risk does not exist when manual compensation or non-compensated values are used.

7.5.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
I> 1				
_:16231:1	I> 1:Mode		• off • on • test	off
_:16231:2	I> 1:Operate & flt.rec. blocked		• no • yes	no
_:16231:100	I> 1:Measured value		• compensated • non-compensated	compensated
_:16231:3	I> 1:Threshold	1 A @ 100 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 100 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	0.200 A
		5 A @ 50 Irated	0.15 A to 175.00 A	1.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.200 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	1.000 A
_:16231:6	I> 1:Operate delay		0.00 s to 60.00 s	0.05 s

7.5.4.4 Information List

No.	Information	Data Class (Type)	Type
I> 1			
_:16231:81	I> 1:>Block stage	SPS	I
_:16231:54	I> 1:Inactive	SPS	O
_:16231:52	I> 1:Behavior	ENS	O
_:16231:53	I> 1:Health	ENS	O
_:16231:55	I> 1:Pickup	ACD	O
_:16231:56	I> 1:Operate delay expired	ACT	O
_:16231:57	I> 1:Operate	ACT	O
_:16231:301	I> 1:Fault position group 1	ACT	O
_:16231:302	I> 1:Fault position group 2	ACT	O

7.5.5 Counter Stage

7.5.5.1 Description

Logic of a Stage

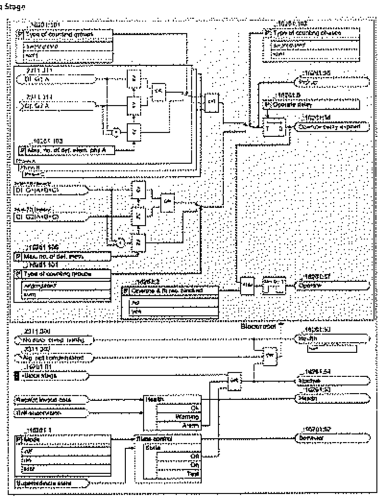

Figure 7-29 Logic Diagram of the Counter Stage

Measured/Input Values

The measured/input values of the counter stage are phase-segregated and group-segregated counter contents that are determined in the **General FB**.

Pickup, Operate Delay

With the parameter Type of counting phases, a selection is made whether the supervision function occurs in a phase-segregated way or with the sum value of the phases. With the parameter Type of counting groups, a selection is made whether the supervision function occurs in a group-segregated way or with the sum value of both groups. If a counter reaches the set threshold, the stage picks up. The pickup starts the time delay. If the time delay has elapsed, the operate indication will be issued.

Automatic Compensation

If the automatic compensation function is enabled, the counter stage is working. If this is not the case, the readiness status of the stage changes to the state *Warning*.

7.5.5.2 Application and Setting Notes

General Notes

- The setting notes for the current-threshold value for counting faulty C-elements are provided in chapter 7.5.3.2 Application and Setting Notes as you must set this parameter across all stages.
- In order to react quickly to the simultaneous fault of many C elements, always use an overcurrent-protection stage I> with a short operate delay (< 100 ms) in addition to the counter stage. This is necessary as the counter function counts each current jump only once, regardless of its height.

Parameter: Type of counting groups

- Default setting (_:16261:101) Type of counting groups = segregated

With the parameter Type of counting groups, you specify whether the group-segregated counter status or the sum value of both group counters are compared to the threshold.

Parameter: Type of counting phases

- Default setting (_:16261:102) Type of counting phases = segregated

With the parameter Type of counting phases, you specify whether the supervision function occurs in a phase-segregated way or with the sum value of the phases.

Parameter: Maximum Number of Faulty Elements, Operate delay

- Default setting (_:16261:103) Max. no. of def. elem. phs A = 10
- Default setting (_:16261:104) Max. no. of def. elem. phs B = 10
- Default setting (_:16261:105) Max. no. of def. elem. phs C = 10
- Default setting (_:16261:106) Max. no. of def. elem. = 10
- Default setting (_:16261:6) Operate delay = 0.00 s

Set the parameters for the specific application.

It is possible to configure several stages for different tasks:

- Reporting only (with or without fault record)
  Use this stage to report 1 or 2 faulty C-elements. To do this, set the parameters Max. no. of def. elem. phs A, Max. no. of def. elem. phs B, Max. no. of def. elem. phs C, or Max. no. of def. elem. to a small value (1 or 2). The parameter Operate delay can be set to 0.
  If you would like to prevent the operate (tripping) and fault logging (fault log and fault record), set the parameter Operate & flt.rec. blocked to yes.
  If you would like to prevent only the operate (tripping) and the fault logging must occur, remove this stage from the interface Trip to the circuit breaker (see also 5.4.2 Structure of the Function Group Interfaces with Circuit-Breaker Function Group).
- Indication with delayed operate
  Use this stage to report in case of some faulty C-elements and to set a relatively long time delay of the operate, for example, 2 hours. During this time, the fault of the C-elements can be clarified. If it is possible to find a solution, the counter status can be reset manually. This way, the stage drops out. If a solution cannot be found within 2 hours, the stage trips and disconnects the capacitor bank.
- Immediate operate
  The stage is used to initiate the operate immediately after a larger number of C-elements became faulty.

7.5.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Counter 1				
_:16261:1	Counter 1:Mode		• off • on • test	off
_:16261:2	Counter 1:Operate & flt.rec. blocked		• no • yes	no
_:16261:101	Counter 1:Type of counting groups		• segregated • sum	segregated
_:16261:102	Counter 1:Type of counting phases		• segregated • sum	segregated
_:16261:103	Counter 1:Max. no. of def. elem. phs A		1 to 1000	10
_:16261:104	Counter 1:Max. no. of def. elem. phs B		1 to 1000	10
_:16261:105	Counter 1:Max. no. of def. elem. phs C		1 to 1000	10
_:16261:106	Counter 1:Max. no. of def. elem.		1 to 1000	10
_:16261:6	Counter 1:Operate delay		0.00 s to 10000.00 s	0.00 s

7.5.5.4 Information List

No.	Information	Data Class (Type)	Type
Counter 1			
_:16261:81	Counter 1:>Block stage	SPS	I
_:16261:54	Counter 1:Inactive	SPS	O
_:16261:52	Counter 1:Behavior	ENS	O
_:16261:53	Counter 1:Health	ENS	O
_:16261:55	Counter 1:Pickup	ACD	O
_:16261:56	Counter 1:Operate delay expired	ACT	O

No.	Information	Data Class (Type)	Type
_:16261:57	Counter 1:Operate	ACT	O

7.6 Peak Overvoltage Protection for Capacitors

7.6.1 Overview of Functions

The **Peak overvoltage protection for capacitors** (ANSI 59C) function protects capacitors against:

- Peak overvoltages that stress the dielectric medium in the capacitor causing accelerated aging
- Peak overvoltages that in extreme cases can destroy the dielectric medium in the capacitor

7.6.2 Structure of the Function

The **Peak overvoltage protection for capacitors** function can be applied in the **Capacitor bank** function group.

3 types of stages are available:

- Stage with inverse-time characteristic curve according to IEC and IEEE Standards
- Stage with definite-time characteristic curve
- Stage with user defined characteristic curve

The function is preconfigured at the factory with a stage having an inverse-time characteristic curve and a stage having a definite-time characteristic curve.

Within the function, the following maximum number of stages can be operated simultaneously:

- 1 stage with an inverse-time characteristic curve
- 4 stages with a definite-time characteristic curve
- 1 stage with a user-defined characteristic curve

Figure 7-30 Structure/Embedding of the Function

7.6.3 Stage with Inverse-Time Characteristic Curve

7.6.3.1 Description

Logic of the Stage

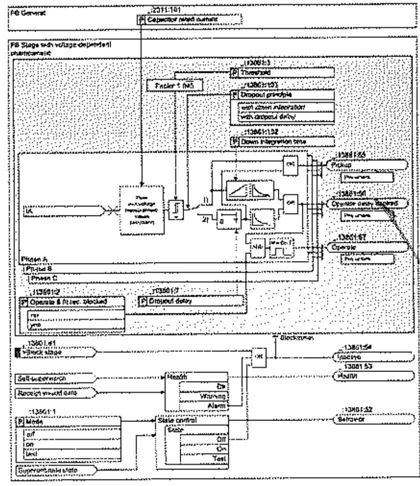

Figure 7-31 Logic Diagram of the Stage with Inverse-Time Characteristic Curve

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(1) With down integration time
(2) With dropout delay

Measurand, Method of Measurement

The function calculates the peak voltage in a phase-segregated way from the fundamental component and superimposed harmonics. Integration of the phase currents then yields the voltage. This approach captures the higher harmonics considerably better since they are transferred better by current transformers than by voltage transformers.

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The resulting measurand is $\hat{U}V_{C,rated}(t)$. The threshold value for the stage is thus set as a referenced quantity.

The phase-selective peak overvoltages $\hat{U}V_{C,rated}(t)$ are available as measured values for display or further processing.

Pickup, Tripping and Dropout Behavior with the Inverse-Time Characteristic Curve

If the measurand $\hat{U}V_{C,rated}(t)$ exceeds 1.045 times the set threshold value (for example, 1.045 · 1.1 = 1.15), pickup occurs and the inverse-time characteristic curve is then followed. For each input value that exceeds the pickup value (1.045 × threshold value), the time value T_{trip} is calculated. An integrator accumulates the value $1/T_{trip}$. When the accumulated integral reaches the fixed value of 1, the stage trips.

If the measurand falls below 1.045 times the set threshold value (pickup value), processing of the characteristic (accumulation of the time values) stops. In the hysteresis region between the pickup value and dropout value (95 % of the pickup value, for example, 0.95 · 1.15 = 1.0925), the integral value remains unchanged. The stage, however, remains in the picked up state.

Use the parameter Dropout principle to select the method for the dropout of the stage:

- **Method with down integration time:**
  If the measurand falls below the dropout threshold, the pickup drops out immediately. If the value drops below the pickup threshold, the internal integral value that depends on the selected Down integration time is slowly reduced. The Down integration time defines the duration in order to reduce the internal integral value linear from 100 % to 0 %. The internal integral value is limited to 100 % and is reached with the tripping function.
- **Method with dropout delay:**
  If the measurand falls below the dropout threshold, the pickup drops not out immediately. The pickup remains for the duration of the set Dropout principle. The integral value remains frozen during this time. If the pickup value is not exceeded again during this time, a dropout occurs and the integral value is reset to 0. If the pickup value is exceeded during this time again, the integrator continues with the integration of frozen values. The pickup remains active and the Dropout principle is reset.

Inverse-Time Characteristic Curve

The characteristic curve is defined by the Standards IEC 60871-1:2005 and IEEE Std 1036-2010, see Figure 7-32.

The points on the characteristic curve defined in the standards result from a threshold setting of 1.1. Threshold values differing from this value shift the characteristic as shown in Figure 7-32.

Straight-line segments are implemented between the defined points on semi-logarithmic coordinates.

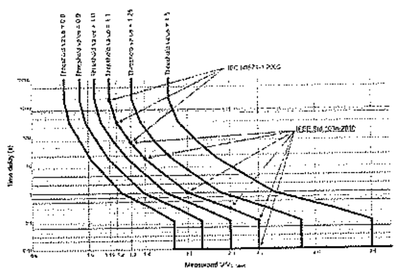

Figure 7-32 Inverse-Time Characteristic Curve

Phase-Segregated Operate Indications

In contrast to what normally occurs in a 3-phase protection device, the function generates phase-segregated operate indications. These indications are needed for supervision applications.

Function Values

Values	Description	Primary	Secondary	% Referenced to
(_:2311:301) VpeakA	Peak voltage phase A	kV	V	Parameter Capacitor reference volt./√3
(_:2311:302) VpeakB	Peak voltage phase B	kV	V	Parameter Capacitor reference volt./√3
(_:2311:303) VpeakC	Peak voltage phase C	kV	V	Parameter Capacitor reference volt./√3

You can find the parameter Capacitor reference volt. of the preceding table in the function block **General** of the function group **Capacitor bank**.

7.6.3.2 Application and Setting Notes

Parameter: Capacitor rated current

- Default setting (_:2311:101) Capacitor rated current = 1000.0 A

With the Capacitor rated current parameter, you set the primary rated current $I_{C,rated}$ of the capacitor or the capacitor bank.

Keep in mind that the rated current of the capacitor considers harmonics in addition to the fundamental component.

The rated current $I_{C,rated}$ is determined from the rated capacity and the rated voltage across the bank. Both values are listed in the Technical Data for the capacitor. Take note of the following:

- The rated voltage for the capacitor also takes harmonics into account. This is not the rated voltage of the system.
- The rated voltage to be used is the voltage applied across the capacitor; depending on the application, this can be a phase-to-phase or phase-to-ground voltage.

Example: Determining the Capacitor Rated Current for a Capacitor in a Star Connection

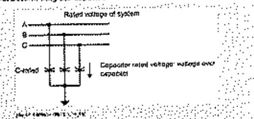

Figure 7-33 Capacitor in Star Connection

Rated voltage of the system	220 kV
Rated capacity per phase	5.233 µF
Capacitor rated voltage $V_{C,rated}$	152.30 kVrms
Rated frequency f	50 Hz

$I_{C,rated} = \omega C \times U_{C,rated} = 2\pi f \times C \times U_{C,rated} = 2 \pi 50 \times 5.233 \cdot 10^{-6} \times 152.3 \cdot 10^{3}$ [Hz · F · V] = 316.1 [A]

Parameter: Threshold

- Default setting (_:13861:3) Threshold = 1.10

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The threshold value is thus set as a referenced quantity.

The points on the characteristic curve defined in the Standards IEC 60871-1:2005 and IEEE Std 1036-2010 result from a threshold setting of 1.10 (see Figure 7-32). Threshold values differing from this shift the characteristic as shown in Figure 7-32.

Siemens recommends using the default setting.

Parameter: Dropout principle

- Default setting (_:13861:103) Dropout principle = with down integration

Use the parameter Dropout principle to select the method for the dropout of the stage:

Parameter Value	Description
with down integration	If the measurand for the dropout threshold falls below the limit, the pickup drops out immediately. If the value drops below the pickup threshold, the internal integral value that depends on the selected down integration time is reduced from 100 % to 0 %.
with dropout delay	If the measurand falls below the dropout threshold, the measurand remains active for the duration of the preset dropout delay. The integral value remains frozen during this time.

Parameter: Down integration time

- Default setting (_:13861:102) Down integration time = 3.00 min

Use the parameter Down integration time in order to determine the duration until the internal integration value is linearly reduced from 100 % to 0 %.

For example, if the integration value is 52 %, a duration of 52 % · down integration time is required until the integration value 0 % is reached. When using this parameter, the preloading of a capacitor can be considered and therefore released quicker.

If you are knowledgeable about recovery time of stressed capacitors, they can be considered with this parameter.

Parameter: Dropout delay

- Default setting (_:13861:7) Dropout delay = 1.00 s

The parameter Dropout delay can be used to prevent resetting of the integral value in the event that the measured value briefly falls below the dropout threshold.

7.6.3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Capacitor rated current		1.0 A to 100000.0 A	1000.0 A
Inverse-T 1				
_:13861:1	Inverse-T 1:Mode		• off • on • test	off
_:13861:2	Inverse-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13861:103	Inverse-T 1:Dropout principle		• with dropout delay • with down integration	with down integration
_:13861:3	Inverse-T 1:Threshold		0.80 p.u. to 3.00 p.u.	1.10 p.u.
_:13861:102	Inverse-T 1:Down integration time		1 min to 1500 min	3 min
_:13861:7	Inverse-T 1:Dropout delay		0.00 s to 3600.00 s	1.00 s

7.6.3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:VpeakA	MV	O
_:2311:302	General:VpeakB	MV	O
_:2311:303	General:VpeakC	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Inverse-T 1			
_:13861:81	Inverse-T 1:>Block stage	SPS	I
_:13861:54	Inverse-T 1:Inactive	SPS	O
_:13861:52	Inverse-T 1:Behavior	ENS	O
_:13861:53	Inverse-T 1:Health	ENS	O

No.	Information	Data Class (Type)	Type
_:13861:55	Inverse-T 1:Pickup	ACD	O
_:13861:301	Inverse-T 1:Down integr. running	SPS	O
_:13861:56	Inverse-T 1:Operate delay expired	ACT	O
_:13861:57	Inverse-T 1:Operate	ACT	O

7.6.4 Stage with Definite-Time Characteristic Curve

7.6.4.1 Description

Logic of the Stage

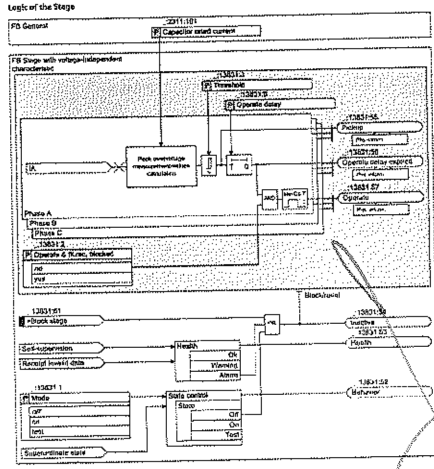

Figure 7-34 Logic Diagram of the Stage with Definite-Time Characteristic Curve

Measurand, Method of Measurement

The function calculates the peak voltage in a phase-segregated way from the fundamental component and superimposed harmonics. Integration of the phase currents then yields the voltage. This approach captures the higher harmonics considerably better since they are transferred better by current transformers than by voltage transformers.

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The resulting measurand is $ÛV_{r,peak}(t)$. The threshold value for the stage is thus set as a referenced quantity.

The phase-segregated peak overvoltages $ÛV_{r,peak}(t)$ are available as measured values for display or further processing.

Pickup, Tripping and Dropout Behavior with the Definite-Time Characteristic Curve

If the measured $ÛV_{r,peak}(t)$ exceeds the set threshold value, pickup occurs and the tripping delay starts. If the measurand remains above the dropout value (95 % of the threshold value) during the tripping delay, the stage trips.

Phase-Segregated Operate Indications

In contrast to what normally occurs in a 3-phase protection device, the function generates phase-segregated operate indications. These indications are needed for supervision applications.

Function Values

For the detailed information of the function values, refer to Function Values, Page 968.

7.6.4.2 Application and Setting Notes

Parameter: Capacitor rated current

- Default setting (_:2311:101) Capacitor rated current = 1000.0 A

You can find the setting notes for the parameter Capacitor rated current under Parameter: Capacitor rated current, Page 968.

Parameter: Threshold

- Default setting (_:13831:3) Threshold = 1.10

The peak voltage determined is then set with reference to the rated voltage of the capacitor. The Threshold is thus set as a referenced quantity.

The setting depends on the application of the stage. If this stage is intended to operate as a warning stage, a very sensitive setting of approx. 1.05 can be selected. If the stage is used for instantaneous tripping in addition to the stage with inverse-time characteristic curve, Siemens recommends a setting of ≥ 3.00.

Parameter: Operate delay

- Default setting (_:13831:6) Operate delay = 3.00 s

The setting depends on the application of the stage. If this stage is intended to operate as a warning stage, the time delay can be selected in a range of seconds. If the stage is used for instantaneous tripping in addition to the stage with inverse-time characteristic curve, the Operate delay can be set to 0.00 s.

7.6.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:101	General:Capacitor rated current		1.0 A to 100000.0 A	1000.0 A
Definite-T 1				
_:13831:1	Definite-T 1:Mode		• off • on • test	off
_:13831:2	Definite-T 1:Operate & flt.rec. blocked		• no • yes	no
_:13831:3	Definite-T 1:Threshold		0.80 p.u. to 10.00 p.u.	5.00 p.u.
_:13831:6	Definite-T 1:Operate delay		0.01 s to 3600.00 s	0.03 s

7.6.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:301	General:VpeakA	MV	O
_:2311:302	General:VpeakB	MV	O
_:2311:303	General:VpeakC	MV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Definite-T 1			
_:13831:81	Definite-T 1:>Block stage	SPS	I
_:13831:54	Definite-T 1:Inactive	SPS	O
_:13831:52	Definite-T 1:Behavior	ENS	O
_:13831:53	Definite-T 1:Health	ENS	O
_:13831:55	Definite-T 1:Pickup	ACD	O
_:13831:56	Definite-T 1:Operate delay expired	ACT	O
_:13831:57	Definite-T 1:Operate	ACT	O

7.6.5 Stage with User-Defined Characteristic Curve

7.6.5.1 Description

This stage is structured the same way as the stage with a voltage-dependent characteristic (see chapter 7.6.3.1 Description). The only difference is that you can define the characteristic curve as desired. This means that you can also define a dropout characteristic curve. This makes the dropout delay parameter superfluous and unneeded.

User-Defined Characteristic Curve

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

Pickup and Dropout Behavior with the User-Defined Characteristic Curve

If the measured $ÛV_{r,peak}(t)$ exceeds the threshold value, the characteristic is followed. An integrating method of measurement summarizes the weighted time. The weighted time results from the characteristic curve. This means that the time associated with the present measured value is determined from the characteristic curve. Once the weighted time exceeds the value 1, the stage operates.

If the measured value falls below 95 % of the set threshold value, the dropout is initiated. The pickup will be indicated as clearing. The weighted time results from the dropout characteristic curve. The integral value is reduced until it reaches 0.

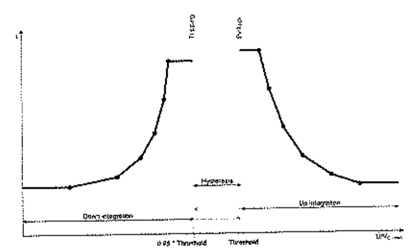

Figure 7-35 Pickup Behavior and Dropout Behavior when Using a User-Defined Characteristic Curve

7.6.5.2 Application and Setting Notes

This stage is structured the same way as the stage with a inverse-time characteristic (see chapter 7.6.3.2 Application and Setting Notes). The only difference is that you can define the characteristic curve as desired. This chapter provides only application and setting notes for setting characteristic curves.

Parameter: Voltage/Time Value Pairs (from the Operate Curve)

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

Set the voltage to a multiple of the threshold value. In order to obtain a simple relation, Siemens recommends setting the Threshold parameter to 1.00. You can change the threshold value setting afterwards if you want to shift the characteristic curve.

Set the time value in seconds. The characteristic curve is shifted via the Time dial parameter.

Set the number of value pairs to be used with DIGSI. You can define a maximum of 30 value pairs.

> **NOTE**
> The value pairs must be entered in continuous order.

Parameter: Time dial

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

Use the Time dial parameter to displace the characteristic curve in the time direction.

Where no time grading of tripping and thus no shifting of the characteristic curve is required, leave the parameter Time dial at 1.

Parameter: Voltage/Time Value Pairs (from the Dropout Characteristic Curve)

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

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

Set the time value in seconds. The characteristic curve is shifted via the Time dial parameter.

Set the number of value pairs to be used with DIGSI. You can define a maximum of 30 value pairs.

> **NOTE**
> The value pairs must be entered in continuous order.

7.6.5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:1	User curve #:Mode		• off • on • test	off
_:2	User curve #:Operate & flt.rec. blocked		• no • yes	no
_:3	User curve #:Threshold		0.80 p.u. to 3.00 p.u.	1.10 p.u.
_:101	User curve #:Time dial		0.05 to 15.00	1.00

7.6.5.4 Information List

No.	Information	Data Class (Type)	Type
User curve #			
_:81	User curve #:>Block stage	SPS	I
_:54	User curve #:Inactive	SPS	O
_:52	User curve #:Behavior	ENS	O
_:53	User curve #:Health	ENS	O
_:55	User curve #:Pickup	ACD	O
_:56	User curve #:Operate delay expired	ACT	O
_:57	User curve #:Operate	ACT	O
_:301	User curve #:Down integr. running	SPS	O

7.7 Voltage Differential Protection for Capacitors

7.7.1 Overview of the Functions

The function Voltage-differential protection (ANSI 87V) can be applied if the capacitor offers a voltage tap to measure the 3-phase voltage within the capacitor installation. The function:

- Calculates the differential voltage between bus and tap voltage by applying a matching factor
- Works as a capacitor unbalance function for protection of faults in capacitor elements (C elements)

7.7.2 Structure of the Function

The function Voltage-differential protection is used in the function group Capacitor bank. The function is preconfigured at the factory with one protection stage V_{dif} >.

A maximum of 4 protection stages V_{dif} > can be operated simultaneously in the function.

The General functionality (including compensation) works across all stages.

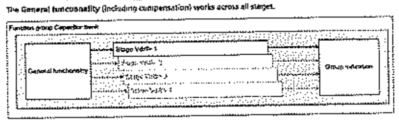

Figure 7-36 Structure of the Function Voltage-Differential Protection

7.7.3 General Functionality

7.7.3.1 Description

The General functionality is structured in the following parts:

- Calculation of the differential voltage V_{dif}
- Compensation of an operational differential voltage V_{dif}

Logic for Calculation and Compensation

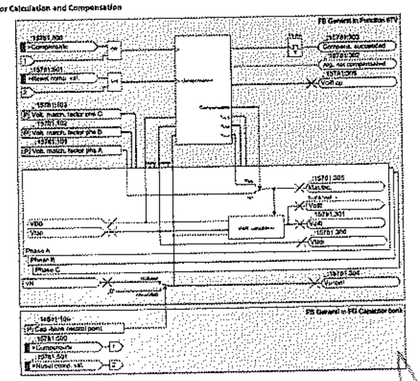

Figure 7-37 Logic Diagram of the General Functionality

Measurands, Method of Measurement

The function receives the 3-phase bus and tap voltage measurands (see also V_{bb} and V_{tap} in Figure 7-37) via the 3-phase voltage and 3-phase voltage CB tap interfaces of the function group Capacitor bank. For an isolated capacitor-bank system, the function receives the capacitor-bank neutral-point voltage V_N via the Voltage unbalance interface. The method of measurement used processes the sampled voltage values and filters out the fundamental component numerically.

The compensated or not compensated differential voltage is provided to the protection stage for evaluation.

Voltage Matching Factor

The phase-selective voltage matching factor k is used as a multiplier for the tap voltage to obtain an equivalent voltage value compared to the bus voltage. The voltage matching factor k is obtained either from the parameter Volt. match. factor phs A, Volt. match. factor phs B, and Volt. match. factor phs C or from the compensation functionality. If the compensation is carried out, the function calculates the voltage matching factor k through dividing the measured bus voltage by the measured tap voltage.

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Calculation of the Differential Voltage

The calculation of the differential voltage depends on the capacitor bank neutral-point grounding. With the parameter Cap. bank neutral point, you can set the grounding type.

2 capacitor-bank neutral-point grounding types are as follows:

- Grounded capacitor-bank system

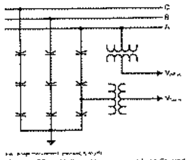

Figure 7-38 Voltage Measurement for a Grounded Capacitor-Bank System

The following formula is used to calculate the differential voltage $V_{d,ff}$ of phase A:

$V_{diff,A} = |V_{bus,A} \cdot k_A - V_{tap,A}|$

$V_{bus,A}$	Voltage from the busbar, phase A
$V_{tap,A}$	Voltage from the tap, phase A
k_A	Voltage matching factor, phase A

This calculation also applies in the calculation of the V_{diff} of phase B and phase C.

The voltage measuring points are connected with the corresponding function-group interfaces.

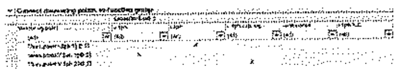

Figure 7-39 Connecting Measuring Points to the Function Group Capacitor Bank for the Grounded Capacitor-Bank System

- Isolated capacitor-bank system

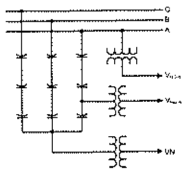

Figure 7-40 Voltage Measurement for an Isolated Capacitor Bank System

The following formula is used to calculate the differential voltage V_{diff} of phase A:

$V_{diff,A} = |(V_{bus,A} - V_N) \cdot k_A - (V_{tap,A} - V_N)|$

$V_{bus,A}$	Bus voltage, phase A
$V_{tap,A}$	Tap voltage, phase A
k_A	Voltage matching factor, phase A
V_N	Neutral-point-to-ground voltage

This calculation also applies to the calculation of the V_{diff} of phase B and phase C.

The voltage V_N is obtained by connecting the measuring point V-1ph to the interface $V_{unbalance}$. V-1ph is used for measuring V_N.

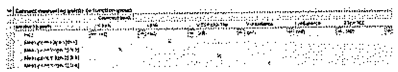

Figure 7-41 Connecting Measuring Points to the Function Group Capacitor Bank for the Isolated Capacitor-Bank System

Both the capacitor-bank tap voltage and the calculated differential voltage are displayed as measured values of the function.

General Notes on the Compensation

An operational differential voltage is added to a differential voltage resulting from faulty capacitor elements. This corrupts the measuring result.

The operational differential voltages can result from the following factors:

- Manufacturing tolerances of the capacitor
- Aging of the capacitor
- Environmental influences, for example, temperature

The compensation eliminates the operational differential voltage by adjusting the voltage matching factors. The adjusted phasors of the matching factor are calculated at the compensation moment, with the following formula (for phase A):

- Grounded capacitor-bank system
  $k_{cp,A} = V_{tap,A} / V_{bus,A}$
- Isolated capacitor-bank system
  $k_{cp,A} = (V_{tap,A} - V_N) / (V_{bus,A} - V_N)$

With

$V_{bus,A}$	Bus voltage, phase A
$V_{tap,A}$	Tap voltage, phase A
$k_{cp,A}$	Calculated matching factor at the compensation moment, phase A
V_N	Neutral point to ground voltage

The calculation also applies to the calculation of the voltage matching factors of phase B and phase C.

The phasors of the calculated voltage matching factors k_{cp} are stored and used for calculation of the differential voltage until the next compensation is applied or until the compensation is reset.

The phasors of the calculated voltage matching factors k_{cp} are displayed as functional measured values after the compensation is applied. In addition, the compensated differential voltage Vdiff.cp is available as functional measured value. Vdiff.cp is the differential voltage at the moment of the compensation compared to the uncompensated status. The compensated differential voltage Vdiff.cp is calculated with the following formula (for phase A):

- Grounded capacitor-bank system
  $V_{diff,cp,A} = |(V_{bus,A} - V_N) \cdot k_A - (V_{tap,A} - V_N)|$
- Isolated capacitor-bank system
  $V_{diff,cp,A} = |V_{bus,A} \cdot k_A - V_{tap,A}|$

With

k_A	Parameter Volt. match. factor phs A
$V_{bus,A}$	Voltage from the busbar, phase A
$V_{tap,A}$	Voltage from the tap, phase A
V_N	Neutral point to ground voltage

This calculation also applies to the calculation of the compensated differential voltage of phase B and phase C.

Manual Compensation via Binary Input Signal

Manual compensation via binary input signals is available.

The following indications describe the status of the compensation:

Indication	Description
Alg. not compensated	The algorithm is not compensated. Compensated values are not available.
Compens. succeeded	If the existing unbalance has been compensated manually, this indication is issued (as transient indication).

By activation of the binary input signal *>Compensate*, the manual compensation is started and the differential voltage that exists at that moment is compensated to 0. The value of V_{diff} becomes 0.

NOTE

If the measured bus voltage or tap voltage is too low, the manual compensation cannot be performed. No manual compensation is carried out under the following conditions:

- In the grounded system:
  $V_{bus} < 10\% \cdot V_{bus,rated}$ or $V_{tap,sec} < 1$ V
- In the isolated system:
  $|V_{bus,prim} - V_{N,prim}| < 10\% \cdot V_{bus,rated,prim}$ or
  $|V_{tap,prim} - V_{N,prim}| \cdot \frac{V_{tap,rated,sec}}{V_{tap,rated,prim}} < 1$ V

Resetting the Compensation

If one of the following conditions is met, the function works in the not compensated status:

- Initial startup of the device before any compensation has been carried out
- Activation of the binary input *>Reset comp. val.*
- Change of the parameter Capacitor-bank neutral point in the function group **Capacitor bank** (refer to chapter *5.4.1 Application and Setting Notes*)

The not compensated status is indicated via the signal *Alg. not compensated*.

Functional Measured Values

Values	Description	Primary	Secondary	% Referenced to
(_:15781:300) Vtap	Tap voltage	kV	V	Parameter Capacitor reference volt./√3
(_:15781:304) Vunbal.	Neutral-point voltage	kV	V	Parameter Capacitor reference volt.
(_:15781:301) Vdiff.	Differential voltage	kV	V	Parameter Capacitor reference volt./√3
(_:15781:206) Vdiff.cp	The compensated differential voltage at the compensation moment	kV	V	Parameter Capacitor reference volt./√3
(_:15781:101) Volt. match. factor phs A	Voltage matching factor of phase A	-	-	-
(_:15781:102) Volt. match. factor phs B	Voltage matching factor of phase B	-	-	-
(_:15781:103) Volt. match. factor phs C	Voltage matching factor of phase C	-	-	-

You can find the parameter Capacitor reference volt. in the function block **General** of the function group **Capacitor bank**.

NOTE

If the function works in the uncompensated status, the values of parameter Volt. match. factor phs A, Volt. match. factor phs B and Volt. match. factor phs C are displayed as functional measured values of the voltage matching factors. And the functional measured values of Vdiff.cp are shown as —.

7.7.3.2 Application and Setting Notes

Parameter: Volt. match. factor phs A, Volt. match. factor phs B and Volt. match. factor phs C

- Default setting (_:15781:101) Volt. match. factor phs A = 2.0000
- Default setting (_:15781:102) Volt. match. factor phs B = 2.0000
- Default setting (_:15781:103) Volt. match. factor phs C = 2.0000

The phase selective parameters Volt. match. factor phs A, Volt. match. factor phs B and Volt. match. factor phs C are applied as multiplier for the primary tap voltage to calculate the differential voltage. It depends on the position of the tap voltage measurement in the specific capacitor installation. The setting is defined as the ratio of the capacitor-bank reference voltage to the tap voltage.

EXAMPLE

The application consists of:

- Capacitor-bank busbar, with a rated voltage of 345 kV
- Capacitor bank, consisting of 15 can levels in series
- Capacitor-bank tap voltage measurement between level 14 and 15

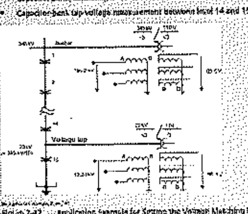

Figure 7-42 Application Example for Setting the Voltage Matching Factor

Capacitor-bank bus voltage as phase-to-phase voltage (It equals to a phase-to-ground voltage of 199.2 kV)	345 kV
Capacitor-bank tap voltage as phase-to-phase voltage (It equals a phase-to-ground voltage of 13.28 kV)	23 kV
Voltage matching factors are set as: (including parameters Volt. match. factor phs A, Volt. match. factor phs B, and Volt. match. factor phs C)	345 kV/23 kV = 15

The voltage measuring points must be set as indicated in the figure:

Busbar transformer, rated primary voltage:	345 kV
Busbar transformer, rated secondary voltage:	110 V
Tap transformer, rated primary voltage:	23 kV
Tap transformer, rated secondary voltage:	110 V

Under normal operation, these settings result in a differential voltage of approximately 0 V and in the primary and secondary measured voltage values as indicated in the 7.7.3.2 Application and Setting Notes.

NOTE

The sound secondary tap voltage must not be smaller than 1 V. Otherwise the function cannot work properly. Fulfill this condition by applying an appropriate voltage transformer for the tap voltage. Siemens recommends applying a tap voltage transformer which provides under normal operation a secondary voltage in the area of the rated secondary voltage.

EXAMPLE

In the grounded system:
Ratio of the capacitor-bank bus voltage to the tap voltage: matching factor k = 400 kV/400 V = 1000
Busbar transformer, rated primary voltage: 400 kV
Busbar transformer, rated secondary voltage: 100 V
To ensure an optimal tap-voltage measurement, the following transformer ratio is recommended:
Tap transformer, rated primary voltage: 400 V
Tap transformer, rated secondary voltage: 100 V

504

7.7.4 Description Protection Stage

7.7.4.1 Description

Logic of the Stage V_{diff}

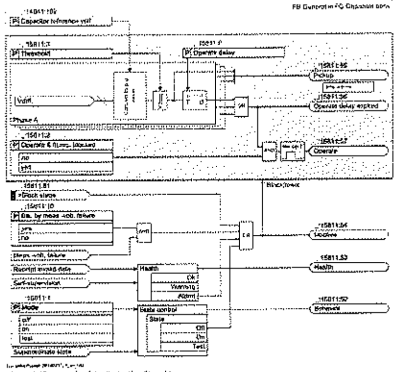

Figure 7-43 Logic of the Protection Stage V_{diff}

Measurand, Pickup and Operate

In the protection stage, the differential-voltage value is converted to a p.u. value in relation to the capacitor-bank reference voltage.

If the converted value exceeds the Threshold value, a *Pickup* indication is issued. If the threshold is exceeded continuously during the operate delay, an *Operate* signal is issued.

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 function Measuring-voltage failure detection (see section 9.3.2.1 Overview of Functions). The parameter Blk. by meas.-volt. failure can be set so that the 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 parameter Blk. by meas.-volt. failure can be set so that the measuring voltage failure detection blocks the stage or does not block it.

7.7.4.2 Application and Setting Notes

Parameter: Threshold

- Default setting (_:15811:3) Threshold = 0.200 p.u.

The parameter Threshold is set as a p.u. value related to the parameter Capacitor bank reference voltage in the function group Capacitor bank.

The setting of the parameter Threshold depends on the differential voltage that occurs with the number of defective C elements for which a warning indication or a trip command shall be generated. Determine this differential voltage and set the Threshold slightly lower, for example, to 80 % of the value.

Parameter: Operate delay

- Default setting (_:15811:6) Operate delay = 1.00 s

Set the parameter Operate delay for the specific application.

Parameter: Blk. by meas.-volt. failure

- Default setting (_:15811:10) Blk. by meas.-volt. failure = *yes*

You can use the parameter Blk. by meas.-volt. failure 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. This binary input is available in the voltage transformers connected to the bus voltage and capacitor-bank tap voltage. The binary input is also available in the voltage transformer connected to the VN voltage in case of an isolated capacitor bank.

Parameter Value	Description
no	The stage Vdiff > is not blocked when a measuring-voltage failure is detected.
yes	The stage Vdiff > is blocked when a measuring voltage failure is detected. Siemens recommends using the default setting, as correct operation of the stage cannot be guaranteed if a measuring-voltage failure occurs.

7.7.4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:15781:101	General:Volt. match. factor phs A		0.5000 to 2000.0000	2.0000
_:15781:102	General:Volt. match. factor phs B		0.5000 to 2000.0000	2.0000
_:15781:103	General:Volt. match. factor phs C		0.5000 to 2000.0000	2.0000
Vdiff> 1				
_:15811:1	Vdiff> 1:Mode		• off • on • test	off
_:15811:2	Vdiff> 1:Operate & flt.rec. blocked		• no • yes	no
_:15811:10	Vdiff> 1:Blk. by meas.-volt. failure		• no • yes	yes
_:15811:3	Vdiff> 1:Threshold		0.005 p.u. to 1.000 p.u.	0.200 p.u.
_:15811:6	Vdiff> 1:Operate delay		0.00 s to 60.00 s	1.00 s

7.7.4.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:15781:500	General:>Compensate	SPS	I
_:15781:501	General:>Reset comp. val.	SPS	I
_:15781:302	General:Alg. not compensated	SPS	O
_:15781:303	General:Compens. succeeded	SPS	O
_:15781:300	General:Vstp	WYE	O
_:15781:301	General:Vdiff	WYE	O
_:15781:304	General:Vunbal.	CMV	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O
Vdiff> 1			
_:15811:81	Vdiff> 1:>Block stage	SPS	I
_:15811:54	Vdiff> 1:Inactive	SPS	O
_:15811:52	Vdiff> 1:Behavior	ENS	O
_:15811:53	Vdiff> 1:Health	ENS	O
_:15811:55	Vdiff> 1:Pickup	ACD	O
_:15811:56	Vdiff> 1:Operate delay expired	ACT	O
_:15811:57	Vdiff> 1:Operate	ACT	O

7.8 Differential Protection for Capacitor Banks

7.8.1 Function Overview

The function **Differential protection for capacitor banks** (ANSI 87C):

- Detects ground faults and multiphase short circuits at capacitor banks
- Detects ground faults during the operation of capacitors in systems with a grounded neutral point
- Uses the necessary stabilization procedures during energizing operations
- Trips safely and very fast in the case of internal high-current faults through an additional high-current stage

7.8.2 Structure of the Function

The **Differential capacitor bank protection** function is used in the **Capacitor Bank diff** protection function group. The function is preconfigured by the manufacturer in the corresponding application template depending on the application and can be copied during the engineering into the corresponding function group.

The **Differential capacitor bank protection** function consists of the stages IDiff and IDiff fast. The stages can be blocked, in addition you can switch the stages on and off.

The function group **Capacitor bank side** has the following characteristics:

- The side-related protection settings are performed
- The side-related calculations are performed
- All data (setting values, detected currents) are relayed to the **Capacitor bank Diff** function group

The side related protection functions can run in the **Capacitor bank side** function group, for example overload protection, overcurrent protection, etc.

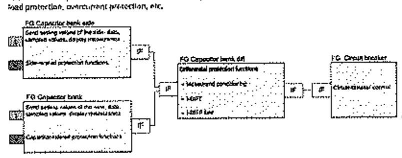

Figure 7-44 Structure/Embedding of the Function

7.8.3 Function Description

Basic Principle of Differential Protection

Differential protection is based on a comparison of currents (Kirchhoff current law). When comparing the current, use is made of the fact that a protected object uses the same current I in a non-faulty operating state on both sides (dotted in Figure 7-45). This current flows into the range being observed on one side and leaves it again on the other side. A current differential is a sure indication of a fault within the protected object. The calculation of the difference is determined through the current-direction detection. The current direction is

defined as positive to the protected object. The current difference results from the vector addition of the currents.

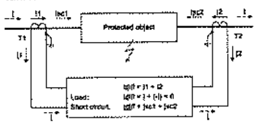

Figure 7-45 Basic Principle of Differential Protection Using the Example of 2 Sides

For safe operation, additional functions are required. The implementation of these additional functions is described in chapter *Differential Protection Function (IDiff), Page 993*.

Current Stabilization

If very large currents flow through the protection range in the case of external faults, with different transmission behavior of the transformers W1 and W2 (Figure 7-45), a corresponding differential current I_{diff} occurs. When this is larger than the corresponding pickup threshold, the device can issue a trip command, even though no fault is present in the protection range. Such a malfunction of the protection is avoided by the restraint current (I_{rest}) and is implemented in the form of a characteristic curve $I_{diff} = f(I_{rest})$.

The largest current of 2 or more measuring points of the protected object is used for stabilization.

The definition for 2 measuring points is:

A trip or differential current is

$I_{diff} = |I_1 + I_2|$

as well as a restraint current of

$I_{rest} = Max (|I_1|; |I_2|)$

For more than 2 measuring points, this definition is expanded. This restraint method allows a reliable trip decision for more than 2 measuring points and different feeding behavior for internal short circuits.

$I_{rest} = Max (|I_1|; |I_2|; ... |I_n|)$

To clarify the effect, 3 important operating states are observed with ideal and adapted measurands.

- Through fault current in healthy operation or externally caused error:
  I_1 flows into the protection range, I_2 flows out of the protection range, that is, negative compared with the prefix definition, thus $I_2 = -I_1$.
  In addition $|I_2| = |I_1|$
  $I_{diff} = |I_1 + I_2| = |I_1 - I_1| = 0$
  $I_{rest} = Max (|I_1|; |I_2|) = |I_1| = |I_2|$
  No tripping quantity ($I_{diff} = 0$); the stabilization (I_{rest}) corresponds to the flowing current.
- Internal short circuit, feed from both sides with equal amount of currents, for example:
  Then $I_2 = I_1$; in addition $|I_2| = |I_1|$:
  $I_{diff} = |I_1 + I_2| = |I_1 + I_1| = 2 \cdot |I_1|$
  $I_{rest} = Max (|I_1|; |I_2|) = |I_1| = |I_2|$
  The tripping quantity (I_{diff}) is twice as large as the short-circuit current and the restraining quantity (I_{rest}).

- External short circuit, feed only from one side:
  Then $I_2 = 0$
  $I_{diff} = |I_1 + I_2| = |I_1 + 0| = |I_1|$
  $I_{rest} = Max (|I_1|; |I_2|) = |I_1|$
  The tripping quantity (I_{diff}) and the restraining quantity (I_{rest}) are of the same size and correspond to the short-circuit current.

Additional Stabilization with External Short Circuits

In case of an external short circuit, high short-circuit currents flowing through can lead to current-transformer saturation. This saturation can be more or less strongly pronounced at the measuring points, and in this way simulate a differential current. The differential current can lie in the tripping range of the characteristic curve for a certain time and lead to unwanted tripping without any particular measures. In accordance with Figure 7-46, there are 2 typical scenarios:

- High-current, external short circuit
  First, the current on both sides is transferred and leads to a large restraint current. After this, a transformer becomes saturated, resulting in a differential current I_{diff} that can exceed the operate curve. Simultaneously, the restraint current I_{rest} drops. Once the transformer is no longer saturated, the differential current decreases and falls below the characteristic curve.
- Low-current, external short circuit
  Current transformers can also become saturated through the large direct current time constant (switching of transformers, motors), but small currents flowing through. This manifests itself as a phase-angle rotation of the current. Exceeding the characteristic curve in a non-stabilized area is possible.

Intelligent saturation-detection methods capture this state and lead to a temporarily limited blocking of the Differential protection function.

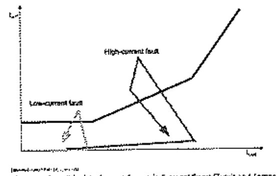

Figure 7-46 Principle Current Course in External Short Circuit and Temporary Current-Transformer Saturation on One Side

Inrush-Current Detection

The inrush-current detection evaluates the calculated instantaneous values of the differential current. The inrush current develops with Sympathetic Inrush – connection of a parallel transformer or Recovery Inrush – inrush current subsequent to returning voltage after fault in the system considerably higher than in the side currents. An assignment to the corresponding blocking phases is possible only in the differential current due to the vector-group correction.

The inrush-current detection is activated when the pickup characteristic is exceeded. It is deactivated when it is blocked by an external fault.

For inrush-current detection, 2 methods working in parallel are used:

- **Share of the 2nd harmonic relative to the fundamental component in the differential current ($I_{2nd\ harm}/I_{fund}$)**
  As Figure 7-47 also shows, the 2nd harmonic is clearly pronounced in the inrush current. If the share of the 2nd harmonic exceeds the set threshold value (parameter: 2nd harmonic content), a phase-segregated blocking occurs. The harmonics develop differently in the different phases. If exceeding of the 2nd harmonic is detected in a phase, it may be necessary to block all phases simultaneously. This blocking must be limited with regard to time and is controlled by the parameter Crossblock. time 2nd har.. The correct positioning of the filter windows is controlled by the internal pickup.

If you want only one method to be active, the other method can be changed to inactive. For this, parameter Blocking with 2. harmonic = no is used.

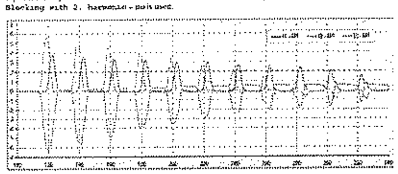

Figure 7-47 Inrush Current with Pronounced Flat Areas

Figure 7-48 shows the logical input and output signals.

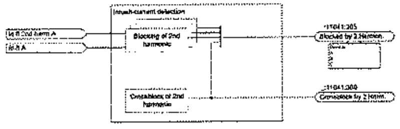

Figure 7-48 Logic Inrush-Current Detection

Logic of the Function

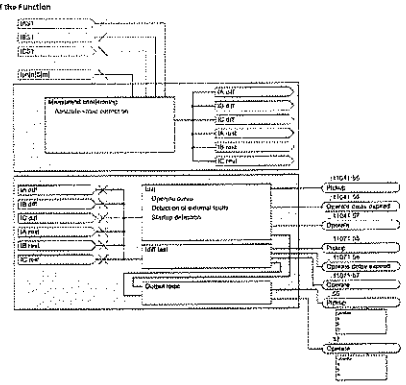

Figure 7-49 Logic Diagram of the Capacitor Bank Differential Protection Function

Measurand Processing

Absolute-Value Correction

Since the current transformers cannot be adapted exactly to the rated currents of the protected object with regard to their primary rated data, a standardization to the nominal sizes of the protected object takes place. The conversion occurs every sampling time (thus, for instantaneous values). The differential protection function processes 20 sampled values per period. In addition, the sampled values tracked are used. A high degree of accuracy can be attained over the entire tracking range (from 10 Hz to 80 Hz).

The Idiff-fast stage works on non-frequency tracked values and thus, implements fast operate times with low frequencies.

The absolute value is adapted via the following formula:

$$i_{phs}^{*} = k \cdot i_{phs}$$

$$\text{with } k = \frac{I_{rated\,prim,\,Str}}{I_{rated\,obj,\,Str}} = \frac{I_{rated\,prim,\,Str}}{\frac{S_{rated,\,obj}}{V_{rated,\,Str}\sqrt{3}}}$$

i_{phs}^{*}	Adapted instantaneous value per phase (x = A, B, C)
i_{phs}	Instantaneous value per phase (x = A, B, C)
k	Correction value per measuring point
$I_{rated\,prim,\,Str}$	Primary transformer rated current per measuring point
$I_{rated\,obj,\,Str}$	Primary rated current of the protected object
$S_{rated,\,obj}$	Reference power (maximum rated apparent power of the protected object)
$V_{rated,\,Str}$	Rated voltage of the respective side (measuring point) of the protected object

NOTE

For more than 2 capacitor bank sides (feed feeder), the winding with the highest power is used as the reference winding. If several sides have the same highest amount of power, then the highest current side is selected as reference side. The absolute value of the neutral-point transformer is also adapted according to the previous formula. In this case, the absolute value should be adapted to the side with the greatest power.

Vector-Group Correction

The vector groups of the capacitor bank sides occur due to couplings that are different on each side. Therefore, the measured currents cannot be used directly for summation. The vector-group correction replicates the coupling of the capacitors and makes the measured currents comparable. The correction occurs such that each side is converted to vector group 0. Since you are in the 3-phase system, the conversion occurs via matrices which are stored for the respective vector-group type. The general description is given in the following formula. In the same calculation step, the absolute value is corrected:

$$\begin{bmatrix} i_A^* \\ i_B^* \\ i_C^* \end{bmatrix} = k \cdot M_{(k)} \cdot \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix}$$

with

i_{phs}^{*}	Adapted instantaneous value per phase (x = A, B, C)
i_{phs}	Instantaneous value per phase (x = A, B, C)
k	Absolute-value correction per measuring point
$M_{(k)}$	Correction matrix

Differential Protection Function (Idiff)

A differential current per phase based on the instantaneous value variables is calculated from the processed currents (see section Measurand Processing). The direction of current flow is defined as to the protected object as positive. The fundamental component contribution to the differential current (I_{diff}) is calculated via a Fourier filter (filter length = 1 period (20 sampled values)).

The currents of that measuring point whose RMS value is the largest are used as restraint current. If, for example, the current collapses at a measuring point as a consequence of current-transformer saturation, the measuring point that has the largest current is automatically switched to at the point in time of the calculation.

NOTE

Differential protection does not work with sensitive ground-current transformers. Since sensitive transformers can go into saturation too quickly, false differential currents arise.

$$i_{diff,phsx} = \sum_{m=1}^{N} i_{phsx,Mm} \rightarrow I_{diff,phsx} = FIR(i_{diff,phsx})$$

$$I_{phsx,Mm} = \sqrt{\frac{1}{n}\sum_{k=1}^{n} i^2_{phsx,Mm}(k)}$$

$$I_{rest,phsx} = \underset{m=1}{\overset{N}{MAX}}\, I_{phsx,Mm}$$

with

x	Variable (1, 2, 3) for the phase currents (A, B, C)
m	Variable (1, 2, ..., N) for the measuring points
N	Number of measuring points
n	Number of samples per period (n = 20)
FIR	Fourier filter
MAX	Maximum value determination

Pickup Characteristic

Figure 7-50 shows the pickup characteristic of the differential protection. The characteristic curve branch a represents the sensitivity threshold of the differential protection (parameter Threshold) and considers constant fault currents like magnetizing currents.

The characteristic branch b (parameter Intersection 1 Irest and Slope 1) considers current-proportional faults under normal operating conditions.

These faults can occur for the following reasons:

- Transformation errors in the current transformer and the input transformer of the device
- Adaptation deviations

The characteristic curve branch c (parameter Intersection 2 Irest and Slope 2) protects the differential protection against overfunction in case of high-current external faults and transformer saturation. In this area, transformer saturation can arise due to high short-circuit currents, and because of this, a higher differential current results.

In order to avoid overfunction in the event of external faults with transformer saturation, a logic is implemented that uses the characteristic curve **Additional stabilization of external faults**. If the operating point is located in the additional stabilization area and exceeds the operate curve from there, then the logic becomes active and blocks the differential protection.

The additional stabilization range is derived from the Threshold add-on stabiliz. and Slope 1 parameters.

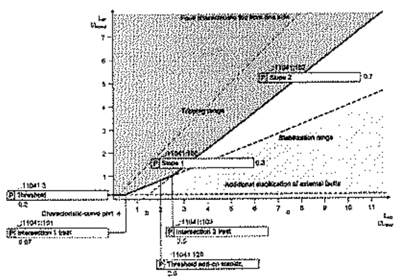

Figure 7-50 Pickup Characteristic of the Differential Protection

If the differential current multiplied by the dropout ratio of 0,7 does not reach the pickup characteristic, the pickup drops out.

Detection of External Faults

To detect external faults with transformer saturation in a reliable way, the measurand curve is evaluated in the Diff.-fast level by means of a detector. The detector has 2 essential tasks:

- **Blocking in the case of a definite high-current external fault**
  The differential current and the restraint current are monitored on a phase basis in the Diff-fast level immediately after fault inception. To ensure the stability of the saturation detection for low saturation-free times of the primary current transformer, estimated values based on the difference quotients of the instantaneous values are used.
  If the estimated restraint current exceeds the Threshold add-on stabiliz. parameter and the expected value of the differential current of all phases is in the additional stabilization range (parameter Slope 1) (Figure 7-50) at the same time, the detector is active and the indication *Blocked by ext. fault phsx* appears. The tripping of the Differential protection function is blocked.
  If an external fault arises and is cleared by the protection responsible for it, the additional stabilization drops out. If the dropout ratio (0,7) of the RMS value of the restraint current does not reach the Threshold add-on stabiliz. parameter (Figure 7-50), the additional stabilization drops out. The indication *Blocked by ext. fault phsx* is reset.
  If the differential current exceeds Slope 2 as a result of transformer saturation, that is, there is a pickup phsx, the blocking is limited in time (parameter Time of add-on stabiliz.).
  Starting with the indication *Blocked by ext. fault phsx*, the other phases can be blocked with it via the Crossblk. time add-on st. parameter. If differential currents due to transformer saturation spread to the other phases through the vector group correction or residual current elimination, this blocking is necessary.

- **Removal of the blocking with a change in fault location from external to internal**
  An internal fault can arise as a consequence of an external fault. This fault change must be recognized and the blocking must be removed. The critical case is a short circuit with current-transformer saturation. The saturation detection examines here the instantaneous values of the differential current. With transformer saturation, the instantaneous values fall below an internal threshold in the saturation-free time. If this threshold is permanently exceeded and a pickup is present in the corresponding phase, an internal error is assumed. The other phases are also examined during the parameterization with cross block.
  The blocking of the tripping is removed and the indication *Blocked by ext. fault phsx* is reset.

DC-Component Detection

Low-current external faults with large DC components can also lead to exceeding of the operate curve. The additional stabilization area is not attained, however.

To avoid an overfunction, the following steps are taken:

- The restraint current $I_{rest,phsx}$ is monitored for a jump.
- If the jump occurs, the DC component is calculated, with a temporal delay (1 period), from the instantaneous value of the restraint current (current at the measuring point with the largest current) $i_{rest,phsx}$ = $i_{phsx,Mm}$. The result is $I_{rest,DC,phsx}$. This current is compared to the restraint current $I_{rest,phsx}$ and is checked for exceeding of the internal threshold.
- The differential current $I_{diff,phsx}$ must lie below the dropout characteristic curve (characteristic curve · 0.7) in all 3 phases.
- If the first 3 points lead to positive results, then the operate curve is raised by the parameter Factor increasing char. with a default setting of 2,3. Here, only the threshold value and the gradient 1 are raised (see Figure 7-51). The indication *Increase of char. (DC)* is output. If the product of parameter Factor increasing char. and Slope 1 exceeds 0,85, the maximum increase of the raised Slope 1 is limited to 0.85.
- As additional criterion, the pickup indication *Pickup* (internal fault is present) or the indication of the additional stabilization *Blocked by ext. fault phsx* (high-current external fault) is sampled. If one of the 2 conditions is present, the characteristic curve increase is stopped. A retroactive pickup no longer resets the characteristic curve increase. A pickup with DC-component detection occurs only if the raised operate curve is exceeded.

If the DC component $I_{rest,DC,phsx}$ falls below the internal dropout threshold, the dropout delay is determined as follows:

It is assumed that the de- and remagnetization of the transformer last equally long. The magnetization is at the highest at the point in time in which the internal dropout threshold is attained. The time is measured from the start of the DC-component detection until the internal dropout threshold is reached. Added to this time are 5 periods and from this, the dropout delay is derived. Following this, the characteristic-curve increase is reset to the original value. Figure 7-52 shows the overall logic.

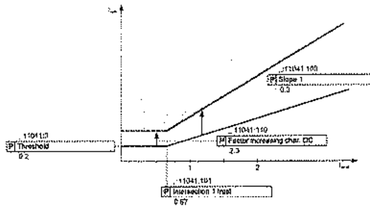

Figure 7-51 Increasing the Characteristic Curve after DC Detection

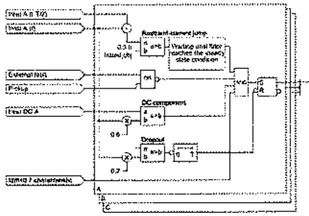

Figure 7-52 Logic DC Detection

Startup Detection

The pickup-value increase is particularly useful in the case of motors. In contrast to transformers, the inrush current with motors is a flowing current. Differential currents can arise, however, by the current transformers having different residual magnetization and being supplied with current at different operating points of their hysteresis. These differential currents are low in fact, but they can lead to overfunction with sensitive setting of the differential protection.

You can use the pickup-value increase at startup as an additional security against overfunction when switching in a previously currentless protected object. If the restraint current falls below a settable value Thresh. startup detection in all phases, the pickup-value increase is activated. The pickup value Threshold

and Slope 1 are raised by the set value in accordance with parameter Factor increasing char. . As a rule here, Slope 1 cannot exceed a value of 0.85.

If the parameter Thresh. startup detection is exceeded, dropout occurs and a timing element (parameter Max. perm. Start. time) is started. Once this time has elapsed, the characteristics curve that was raised in all phases is reset to its original values. Figure 7-53 shows the logic diagram of the pickup recognition and Figure 7-54 the increased characteristic curve.

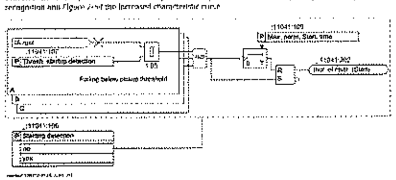

Figure 7-53 Logic Pickup Recognition

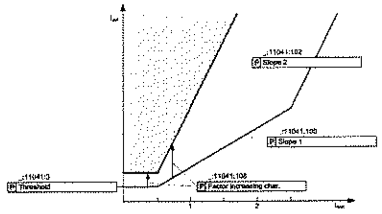

Figure 7-54 Characteristic-Curve Increase at Startup

Trip Logic of the Differential Function Idiff

Figure 7-55 shows the trip logic. If the characteristic curve is exceeded (see Figure 7-50), a pickup occurs. Redirection of the information for tripping can be blocked by the additional functions.

Blocking is possible through use of the following variables:

- Recognition of external faults that can simulate an internal fault through transformer saturation
- Recognition of the connection process (2nd harmonic)

In addition, in case of blocking due to an external error, a Crossblock mechanism comes into effect.

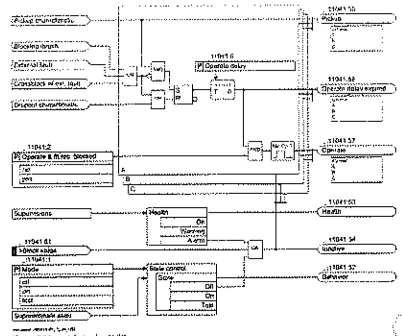

Figure 7-55 Trip Logic of Idiff

Differential Protection Function (Idiff Fast)

As a supplement to the differential protection function (Idiff), the Idiff fast function is available. The main task consists in switching off high-current internal faults in the shortest amount of time. The method controls current-transformer saturation and is stable in the event of external transverse faults (integration in breaker-and-a-half arrangements).

Metrologically, 2 methods are combined.

- Instantaneous-value method
- Filter-based method

Instantaneous-Value Method

Through the instantaneous-values method, an immediate evaluation of the sampled values of the differential $I_{Diff}(t)$ and restraint current $I_{Rest}(t)$ occurs. The absolute-value adapted and vector-group adapted currents (I*) are also the basis. The currents are defined positively to the node. The restraint current is the maximum current of all measuring points.

$$i_{diff,phx}(t) = \left|\sum_{m=1}^{N} i^*_{phx,Mm}(t)\right|$$

$$i_{rest,phx}(t) = \underset{m=1}{\overset{N}{MAX}} \left|i^*_{phx,Mm}(t)\right|$$

with

x Variable (1, 2, 3) for the phase currents (A, B, C)
m Variable (1, 2, ..., N) for the measuring points
N Number of measuring points

The evaluation of the restraint current is used to recognize saturated, high-current external faults.

Figure 7-56 shows the operate curve. The parameter Threshold is set here such that it lies over the maximum fault current flowing. The gradient of the characteristic curve is fixed at 0.8.

In the algorithm, the following conditions are processed:

- Condition 1: The increase of the restraint current $dI_{rest}(t)/dt$ is determined continuously and compared with an internal threshold.
- Condition 2: After that, a comparison determines whether the differential current is larger than the restraint current (characteristic curve Gradient in Figure 7-56): $I_{diff}(t) > 0.8 \cdot I_{rest}(t)$.
- Condition 3: After that, a comparison determines whether the differential current exceeds the parameter Threshold.

When all conditions are met, tripping occurs immediately. If the 1st condition is recognized and not the 2nd condition, then the function is blocked for 300 ms.

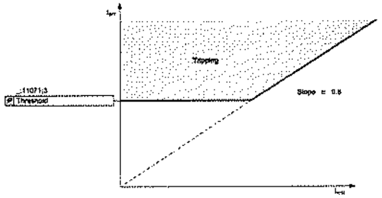

Figure 7-56 Characteristic Curve of Idiff fast

The 2 following figures show the behavior during an internal and an external fault. It is typical for the internal fault (Figure 7-57) that the differential current rises more quickly than the restraint current. After a few sampled values, the trip signal is issued. In case of an external fault, a differential current arises only after transformer saturation occurs. You can always assume, however, that the current is transferred a few milliseconds after occurrence of the fault. In accordance with Figure 7-58, the restraint current is larger than the differential current after occurrence of the fault, but condition 2 is not met and the function is therefore blocked.

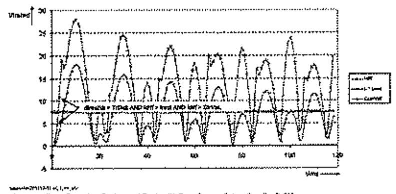

Figure 7-57 Curve Plot for Internal Fault with Transformer Saturation (k= 0.65)

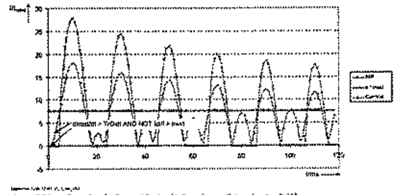

Figure 7-58 Curve Plot for External Faults with Transformer Saturation (k= 0.65)

Fundamental-Component Method

Parallel to the instantaneous value method, the fundamental-component method works with a temporal delay. Here, the same measured values are processed as with the Idiff method. The fundamental component of the differential current I_{diff} and the stabilization value (maximum current of a measuring point) I_{rest} are entered in the operate curve according to Figure 7-56 and the trip decision is made.

Figure 7-59 shows the overall logic.

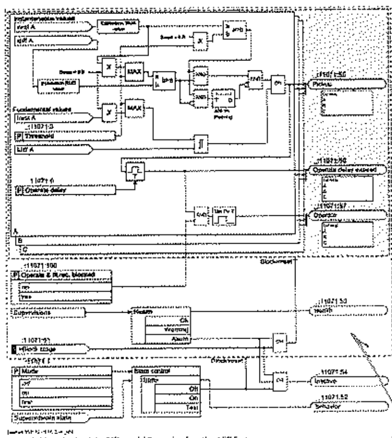

Figure 7-59 Logic of the Differential Protection Function Idiff Fast

Trip Logic of the Differential Protection

A common trip signal is formed from both subfunctions Idiff and Idiff fast. Figure 7-60 shows the respective logic.

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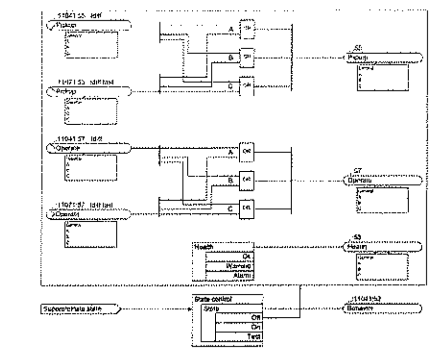

Figure 7-60 Overall Trip Logic

Fault Logging and Fault Recording

A fault is opened with every protection pickup. This means that a fault log and a fault recording are started. Saving of the fault record depends on the setting (see 3.4.3 Function Description). Since pickup and tripping are the same in differential protection, the recording setting can be used with the pickup function. To enable fault recording even with external errors, along with the exceedance of the characteristic curve, a fault record is opened in case of a blocking by an external error as in case of a characteristic-curve increase through component recognition. This has the advantage that you can evaluate the transformer transfer method of the current transformers very well in case of a fault.

7.8.4 Application and Setting Notes

Figure 7-61 shows the application of a differential protection via a capacitor bank in a simplified way.

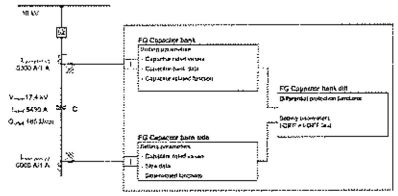

Figure 7-61 Connection Example

The measuring points must be interconnected with the corresponding function groups.

Figure 7-62 shows the corresponding screenshot from DIGSI 5.

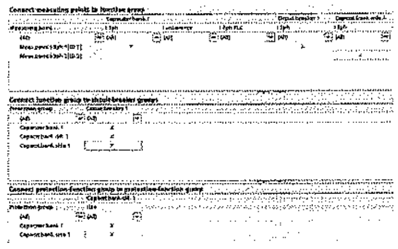

Figure 7-62 Internal Interconnection in DIGSI 5

Function Group Capacitor Bank

This chapter only refers to parameters that are important for the differential protection function application. You can find more information on further parameters in chapter 5.4.3 Application and Setting Notes (Capacitor bank function group).

Parameter: Capacitor reference curr.

- Default setting (_:11041:101) Capacitor reference curr. = 1000 A

With the parameter Capacitor reference curr., you set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and for setting values in percent.

For the Differential protection, these values are used for absolute-value correction (rated current of the protected object).

Depending on the application, you can use the capacitor bank rated current including the harmonics or the capacitor bank fundamental-component current as a reference value.

Function Group Capacitor Bank Side

Proceed with the following settings in the Capacitor bank side function group:

Parameter: Capacitor reference curr.

- Default setting (_:1781:15571:101) Capacitor reference curr. = 1000 A

With the parameter Capacitor reference curr., you set the reference current for the capacitor bank to be protected. The capacitor reference current set here is the reference value for the percentage measured values and for setting values in percent.

For the Differential protection, these values are used for absolute-value correction (rated current of the protected object).

If the capacitor bank is part of a delta connection, the value to be set here can differ from the capacitor reference current set in the Capacitor bank function group (by factor √3). Otherwise, set always the same values.

Depending on the application, you can use the capacitor bank rated current including the harmonics or the capacitor bank fundamental-component current as a reference value.

Parameter: Capacitor reference volt.

- Default setting (_:1781:15571:102) Capacitor reference volt. = 400.00 kV

With the parameter Capacitor reference volt., you set the reference voltage of the capacitor bank to be protected. The reference voltage set here is the reference value for the percentage measured values and for setting values in percent.

Depending on the application, you can use the system rated voltage (busbar voltage) or the capacitor rated voltage as a reference value.

Parameter: Neutral point

- Default setting (_:1781:15571:149) Neutral point = isolated

With the parameter Neutral point, you specify whether the neutral point in the protection range of the differential protection is grounded or isolated. As this is not the case for the described application example, use the default setting isolated.

You can find further information in the 7UT8 Device Manual in chapter 6.2.3 Function Description Neutral-Point Current Treatment.

> **NOTE**
>
> For the described application example, you do not need to change the parameters Winding configuration and Vector group numeral. If the capacitor bank is part of a delta connection, create the phase reference via the vector group.
>
> You can find further information in the 7UT8 Device Manual in chapter 6.2.3 Function Description Vector-Group Correction.

Parameter: Winding configuration

- Default setting (_:1781:15571:104) Winding configuration = Y (Wye)

With the parameter Winding configuration, you set D (Delta) for a delta connection. Another setting option is Y (Wye) for a star connection. The parameter Winding configuration is relevant for the differential protection function. You do not need to change this setting for the described application example.

Parameter: Vector group numeral

- Default setting (_:1781:15571:100) Vector group numeral = 0

This parameter is used to account for phase-angle rotation, which is expressed by a number.

Phase angle rotation	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Vector group numeral	0	1	2	3	4	5	6	7	8	9	10	11

In the function group, the following information is displayed additionally in the setting sheet:

- Side number
- Identification of the measuring points used
- Adaptation factor for the 3-phase measuring point (with reference to the side)

Each Vector group numeral from 0 to 11 can be set to the extent possible. Thus, for example, only even numbers are possible for the vector group Yy and Dd and only odd numbers are possible for Yd and Dy.

You do not need to change this setting for the described application example.

Function Group Capacitor Bank Diff

Proceed with the following settings in the Capacitor bank Diff function group for the IDiff function:

Parameter: Threshold (Setting of the Characteristic-Curve Parameters)

- Default setting (_:11041:3) Threshold = 0.20 I/Irated,obj

You set the pickup threshold for the differential current with this parameter. This is the total current flowing into the protection range during a short-circuit, regardless of how it is distributed on the sides of the protected object. The pickup value is relative to the rated current of the protected object. The default setting of 0.20 I/Irated,obj is a practical value between sensitivity and possible disturbing influence.

Parameter: Intersection 1 Irest

- Default setting (_:11041:101) Intersection 1 Irest = 0.67 I/Irated,obj

The maximum current of the measuring point is used as restraint current. If you have to expect dynamic transmission errors of the current transformer even with small currents, half of the rated current is an appropriate setting value.

Parameter: Slope 1

- Default setting (_:11041:100) Slope 1 = 0.30

With the Slope 1, you avoid an overfunction of the differential protection with low-current external faults as a consequence of current transformer transmission errors (stationary and dynamic faults). The default setting of 0.30 is sufficient for many applications.

Parameter: Intersection 2 Irest

- Default setting (_:11041:103) Intersection 2 Irest = 2.50 I/Irated,obj

> **NOTE**
>
> If you expect transmission problems for the current transformer in case of excessive current flows, set the Slope 2 to a higher value.

The parameter Intersection 2 Irest determines from which restraint current the Slope 2 begins. The default setting 2.50 I/Irated,obj is a practical value.

Parameter: Slope 2

- Default setting (_:11041:102) Slope 2 = 0.70

With the parameter Slope 2, an overfunction of the differential protection is avoided with high-current external faults as a consequence of current-transformer transmission errors (for example, due to saturation). A value greater than or equal to double the value of Slope 1 is practical. As the default setting, 0.70 was selected.

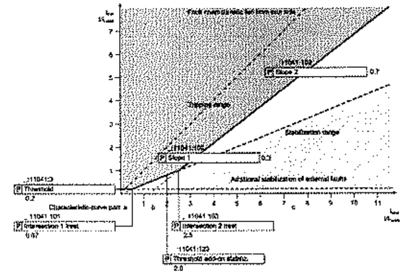

Figure 7-63 Characteristic Curve with the Default Settings

Parameter: Starting detection

- Default setting (_:11041:106) Starting detection = yes

To avoid an overfunction when switching on capacitor banks, you can set the parameter Starting detection = yes. Siemens recommends the setting Starting detection = yes.

Parameter: Thresh. startup detection

- Default setting (_:11041:107) Thresh. startup detection = 0.1 I/Irated,obj

If the restraint current falls below this threshold value, the subsequently set characteristic curve increase becomes effective with activated function. The default setting value of 0.1 I/Irated,obj is recommended for the application.

Parameter: Factor increasing char.

- Default setting (_:11041:108) Factor increasing char. = 2.0

An increase to the value 2.0 has proven itself to be sufficient for many applications.

Parameter: Max. perm. Start. time

- Default setting (_:11041:109) Max. perm. Start. time = 5.0 s

The setting value must be above the maximum inrush time of the connected capacitor bank. To guarantee tripping through the capacitor-bank protection (inrush/starting time supervision) and avoid overfunctions, select a somewhat longer time (factor 1.2 or higher).

Parameter: Factor increasing char. DC (DC-Component Recognition)

- Default setting (_:11041:110) Factor increasing char. DC = 2.3

The DC-component recognition is always active. As a result of the DC components, transmission problems can arise (for example, phase-angle rotations) in current transformers with small currents flowing. For this reason, the Threshold and the Slope 1 are raised by the set factor. The default setting of 2.3 has proven itself with numerous applications.

Parameter: Blocking with 2. harmonic (Inrush-Current Detection)

- Default setting (_:11041:115) Blocking with 2. harmonic = no

The inrush-current detection is not necessary for capacitor-bank applications.

Parameter: 2nd harmonic content

- Default setting (_:11041:116) 2nd harmonic content = 15 %

For many practical applications, the default setting value of 15 % has proven useful. In exceptional cases, the setting value can be decreased with a small proportion of 2nd harmonic. Avoid a setting below 10 %, however. With an internal fault and current-transformer saturation, some proportion of 2nd harmonic also arises. A setting that is too sensitive leads to a blocking of the protection function.

Parameter: Crossblock. time 2nd har.

- Default setting (_:11041:117) Crossblock. time 2nd har. = 0.00 s

Since the inrush currents develop differently in the 3 phases, the pickup value, for example, is not attained in a phase, but the differential current exceeds the characteristic curve. Corrective action creates a mutual blocking. If a time unequal to 0 s is set, the crossblock function works. If an overfunction arises, the setting cannot be made until commissioning takes place. Do not set the duration for an excessive amount of time. Practical values showed a setting between 3 and 5 periods.

Recognition of External Faults

In Figure 7-63 the range Additional stabilization with external fault is represented. The range is described by the parameters Threshold add-on stabiliz. and Slope 1. With an external short circuit, the differential currents can increase beyond this range and reach into the tripping area. With the following parameters, time-limited blocking can be performed.

Parameter: Threshold add-on stabiliz.

- Default setting (_:11041:128) Threshold add-on stabiliz. = 2.00

With the Threshold add-on stabiliz. parameter, you set the pickup value for the additional stabilization. Due to the selected method of measurement, a setting value of 2.00 is practical. The additional stabilization range is limited by the parameters Threshold add-on stabiliz. and Slope 1.

Parameter: Time of add-on stabiliz.

- Default setting (_:11041:129) Time of add-on stabiliz. = 0.30 s

You can use the operate time of the external feeder protection as an orientation for the setting value. Additionally, take into account the circuit-breaker opening time. Thus, the following calculation rule results:

$T_{add} \geq T_{feeder\ protection} + T_{circuit\ breaker}$

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The default value is a practical value. You must adapt the value according to the use case. The value 0 deactivates the recognition of external errors.

Parameter: Cross-blk. time add-on st.

- Default setting (_:11041:130) Cross-blk. time add-on st. = 0.30 s

The additional stabilization acts separately on each phase. However, it can be extended to block all phases. Siemens recommends the activation of the crossblock function by means of a corresponding setting of the time. The set time must be identical to the time that is set for the duration of the additional stabilization.

Protection Stage Idiff Fast

The task of this protection stage is the fast detection of high current internal short circuits (see also Differential Protection Function (Idiff Fast), Page 999). For this reason, the protection stage must always be activated.

Parameter: Threshold

- Default setting (_:11071:3) Threshold = 7.5 I/Irated,obj

Siemens recommends setting the threshold value greater than or equal to the starting current.

7.8.5 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:11041:1	I-DIFF:Mode		• off • on • test	off
_:11041:2	I-DIFF:Operate & flt.rec. blocked		• no • yes	no
_:11041:6	I-DIFF:Operate delay		0.00 s to 60.00 s	0.00 s
Operate curve				
_:11041:3	I-DIFF:Threshold		0.05 I/IrObj to 2.00 I/IrObj	0.20 I/IrObj
_:11041:100	I-DIFF:Slope 1		0.00 to 0.80	0.30
_:11041:101	I-DIFF:Intersection 1 Irest		0.00 I/IrObj to 5.00 I/IrObj	0.67 I/IrObj
_:11041:102	I-DIFF:Slope 2		0.25 to 0.95	0.70
_:11041:103	I-DIFF:Intersection 2 Irest		1.00 I/IrObj to 20.00 I/IrObj	2.50 I/IrObj
Starting detection				
_:11041:106	I-DIFF:Starting detection		• no • yes	no
_:11041:107	I-DIFF:Thresh. startup detection		0.1 I/IrObj to 2.0 I/IrObj	0.1 I/IrObj
_:11041:108	I-DIFF:Factor increasing char.		1.0 to 5.0	2.0
_:11041:109	I-DIFF:Max. perm. Start. time		0.1 s to 180.0 s	5.0 s
DC offset detection				
_:11041:110	I-DIFF:Factor increasing char. DC		1.0 to 5.0	2.3
Inrush blocking				
_:11041:115	I-DIFF:Blocking with 2. harmonic		• no • yes	no
_:11041:116	I-DIFF:2nd harmonic content		10 % to 45 %	15 %

Addr.	Parameter	C	Setting Options	Default Setting
_:11041:117	I-DIFF:Crossblk. time 2nd har.		0.00 s to 200.00 s; ∞	0.00 s
Ext. fault detection				
_:11041:128	I-DIFF:Threshold add-on stabiliz.		1.00 I/IrObj to 20.00 I/IrObj	2.00 I/IrObj
_:11041:129	I-DIFF:Time of add-on stabiliz.		0.00 s to 5.00 s; ∞	0.30 s
_:11041:130	I-DIFF:Cross-blk. time add-on st.		0.00 s to 2.00 s; ∞	0.30 s
I-DIFF fast				
_:11071:1	I-DIFF fast:Mode		• off • on • test	off
_:11071:3	I-DIFF fast:Threshold		0.5 I/IrObj to 35.0 I/IrObj	7.5 I/IrObj
_:11071:6	I-DIFF fast:Operate delay		0.00 s to 60.00 s	0.00 s
_:11071:100	I-DIFF fast:Operate & flt.rec. blocked		• no • yes	no

7.8.6 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:300	General:I diff.	WYE	O
_:2311:301	General:I restr.	WYE	O
_:2311:311	General:I diff. operate phA	MV	O
_:2311:312	General:I diff. operate phB	MV	O
_:2311:313	General:I diff. operate phC	MV	O
_:2311:314	General:I restr. operate phA	MV	O
_:2311:315	General:I restr. operate phB	MV	O
_:2311:316	General:I restr. operate phC	MV	O
_:2311:317	General:Adapt. adjustm. start.	SPS	O
I-DIFF			
_:11041:81	I-DIFF:>Block stage	SPS	I
_:11041:54	I-DIFF:Inactive	SPS	O
_:11041:52	I-DIFF:Behavior	ENS	O
_:11041:53	I-DIFF:Health	ENS	O
_:11041:55	I-DIFF:Pickup	ACD	O
_:11041:56	I-DIFF:Operate delay expired	ACT	O
_:11041:57	I-DIFF:Operate	ACT	O
_:11041:301	I-DIFF:Slope 1	MV	O
_:11041:302	I-DIFF:Incr. of char. (Start)	SPS	O
_:11041:303	I-DIFF:Increase of char. (DC)	SPS	O
_:11041:304	I-DIFF:Blocked by inrush	SPS	O
_:11041:305	I-DIFF:Blocked by 2.Harmon.	ACT	O
_:11041:306	I-DIFF:Crossblock by 2.Harm.	SPS	O
_:11041:312	I-DIFF:Blocked by ext. fault	ACT	O
_:11041:313	I-DIFF:Crossbl. by ext. fault	SPS	O

No.	Information	Data Class (Type)	Type
_:11041:316	I-DIFF:Ph/A int. fault detected	SPS	O
I-DIFF fast			
_:11071:81	I-DIFF fast:>Block stage	SPS	I
_:11071:54	I-DIFF fast:Inactive	SPS	O
_:11071:52	I-DIFF fast:Behavior	ENS	O
_:11071:53	I-DIFF fast:Health	ENS	O
_:11071:55	I-DIFF fast:Pickup	ACD	O
_:11071:57	I-DIFF fast:Operate	ACT	O
_:11071:56	I-DIFF fast:Operate delay expired	ACT	O
Group indicat.			
_:4501:55	Group indicat.:Pickup	ACD	O
_:4501:57	Group indicat.:Operate	ACT	O

7.9 Detuning Supervision for Capacitor Banks

7.9.1 AC-Filter Detuning Supervision

Tuned AC filters serve to provide reactive power and to absorb specific frequencies from the busbar. They usually consist of the upper-voltage side capacitor (for providing reactive power) and the tuning section (for tuning to the frequencies to be absorbed). The tuning section consists of primary C, L and, if required, R elements, refer also to Figure 7-64.

Under normal operation, the RLC characteristics of the filter – the impedances – are identical per phase. A change in the impedance of one phase indicates that the filter characteristic of this phase has changed. This situation (a detuned filter) is not wanted and shall be detected.

The primary elements of the AC filter shall be subject of regular maintenance intervals where the compliance with the tolerances of the rated values specified in the design need to be checked. For the detection of detuning between the maintenance intervals, the protection device can be applied. Detuning supervision for the upper-voltage side voltage capacitor can be achieved by applying the phase-selective Current unbalance function (ANSI 60C), especially by using the counter function.

A criterion for the supervision of the primary elements of the tuning section is the ground or zero-sequence current (3I0) of the AC filter. The fundamental phase current of the AC filter is determined by the phase capacitance of the upper-voltage side capacitor. Consequently, a difference in the phase capacitances of the upper-voltage side capacitor will cause a fundamental ground current. Therefore it is not sufficient for the tuning-section supervision to evaluate only the fundamental ground current. Under normal operation and symmetrical network conditions, the fundamental ground current will be 0. An unbalance in the phase impedances (detuning) will cause a ground current. A detuning of the tuning section will mainly cause harmonics in the ground current. Thus, the RMS value of the ground current needs to be evaluated. For a detuning supervision of the tuning section, the function OCP, ground (ANSI 50N) with the measuring method RMS value is applied. This allows detecting harmonics up to the 50th harmonic with high precision (refer also to technical data).

When selecting the settings (pickup value, operate delay and function mode) for the function OCP, ground (ANSI 50N) the present network connecting conditions must be considered! Otherwise short-term power-system unbalances (for example, 1-pole fast auto reclosing) or statically present harmonics in the zero-sequence system may cause an overfunction. Since the primary elements of the AC filter are directly or inherently protected by other protection functions and due to the possible influence of the network conditions on the function OCP, ground (ANSI 50N), this function should be configured only as alarm function and not as tripping function.

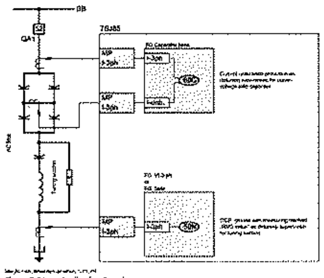

Figure 7-64 Application Overview

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8 Control Functions

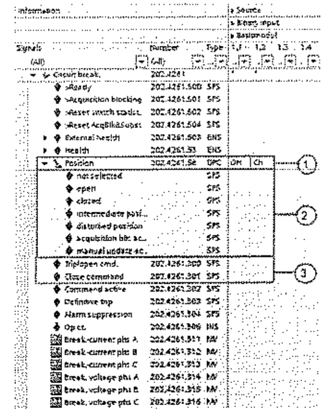
8.1 Introduction

8.1.1 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 control-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 function, other logs are also used.

8.1.2 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.

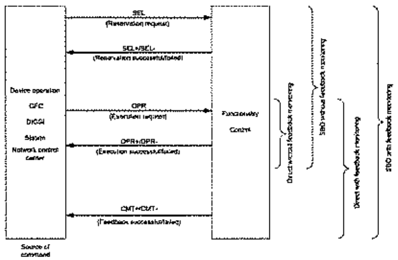


Figure 8-1 Command Sources, Command Types and Control Models

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

8.2 Switching Devices

8.2.1 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).

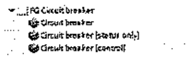


Figure 8-2 Selecting the Circuit-Breaker Switching Device Using the DIGSI Circuit-Breaker Function Group Menu

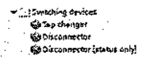


Figure 8-3 Selecting the Remaining Switching Devices Using the DIGSI Switching-Devices Menu

8.2.2 Switching Device Circuit Breaker

8.2.2.1 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.

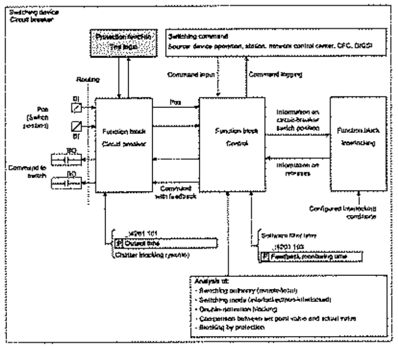


Figure 8-4 Control Function Blocks of the Circuit-Breaker Switching Device

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.

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)

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Function Blocks of the Circuit Breaker

Table 8-1 Function Blocks of the Circuit Breaker Function Group

Function Block	Description	Parameters	Function
Circuit breaker	The Circuit breaker function block of 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 (described in CFC)	The Interlocking functionality generates the releases for switchgear interlocking protection.

The setting values of the parameter can be found in the chapter 8.2.2.2 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 8-2 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 8-3 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 8-4 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 8.2.2.3 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 8.3.1 Command Checks and Switchgear Interlocking Protection.

8.2.2.2 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.

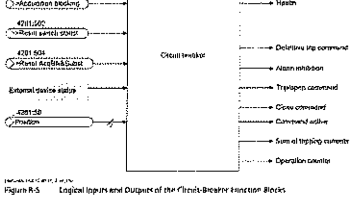

Figure 8-5 Logical Inputs and Outputs of the Circuit-Breaker Function Blocks

Table 8-5 and Table 8-6 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 8-5 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 8-6 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 action or selected switching device (SEL)).	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[7]) reserves the switching device prior to the actual switching operation, 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, 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[8]	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)

[7] In the IEC 61850 standard, reservation is described as Select before Operate (SBO)
[8] This default setting is the standard control model for a switching command in an IEC 61850-compliant system

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.

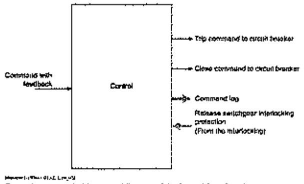

Figure 8-6 Logical Inputs and Outputs of the Control Function Block

Table 8-7 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.

8.2.2.3 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 8-8 Meaning of the Abbreviations of the Connection Variants

Abbreviation	Meaning of the Abbreviations of the Connection Variants
BO	Binary output

Abbreviation	Meaning of the Abbreviations of the Connection Variants
L+; L-	Control voltage
A	Trip command
Cmd	Close command

Table 8-9 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 (H). 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.

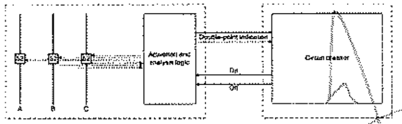

Figure 8-7 3-Pole Circuit Breaker

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1-Pole Triggering

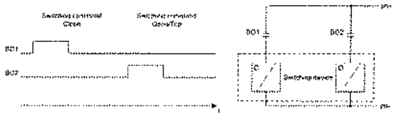


Figure 8-8 1-Pole Triggering

Signals	Number	Type	1.1	1.2	1.3	1.4	1.5
(All)	(All)						
Trip logic	301.5341						
Circuit break.	301.4261						
>Ready	301.4261.500	SPS					
>Acquisition blocking	301.4261.501	SPS					
>Reset switch statist.	301.4261.502	SPS					
>Reset AcqBlk&Subst	301.4261.504	SPS					
External health	301.4261.503	ENS					
Health	301.4261.53	ENS					
Position 3-pole	301.4261.58	DPC					
Position 1-pole phsA	301.4261.459	DPC					
Position 1-pole phsB	301.4261.460	DPC					
Position 1-pole phsC	301.4261.461	DPC					
Trip/open cmd. 3-pole	301.4261.300	SPS		U			
Trip only pole A	301.4261.401	SPS					
Trip only pole B	301.4261.402	SPS					
Trip only pole C	301.4261.403	SPS					
Close command	301.4261.301	SPS	X				

Figure 8-9 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

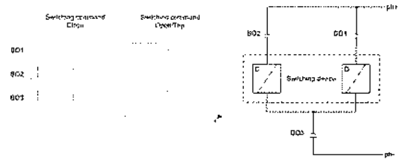


Figure 8-10 1.5-Pole Triggering

Signals	Number	Type	1.1	1.2	1.3	1.4	1.5
(All)	(All)						
Trip logic	301.5341						
Circuit break.	301.4261						
>Ready	301.4261.500	SPS					
>Acquisition blocking	301.4261.501	SPS					
>Reset switch statist.	301.4261.502	SPS					
>Reset AcqBlk&Subst	301.4261.504	SPS					
External health	301.4261.503	ENS					
Health	301.4261.53	ENS					
Position 3-pole	301.4261.58	DPC					
Position 1-pole phsA	301.4261.459	DPC					
Position 1-pole phsB	301.4261.460	DPC					
Position 1-pole phsC	301.4261.461	DPC					
Trip/open cmd. 3-pole	301.4261.300	SPS	U		U		
Trip only pole A	301.4261.401	SPS					
Trip only pole B	301.4261.402	SPS					
Trip only pole C	301.4261.403	SPS					
Close command	301.4261.301	SPS		X	X		

Figure 8-11 1.5 Pole Triggering, Routing in DIGSI

2-Pole Triggering

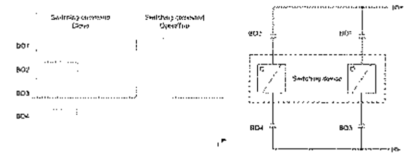


Figure 8-12 2-Pole Triggering

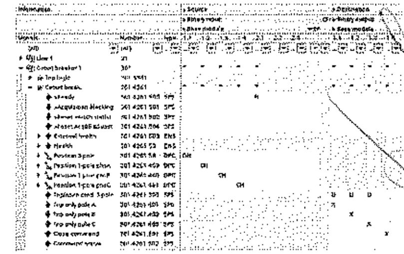


Figure 8-13 2-Pole Triggering, Routing in DIGSI

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 working protection and control functions.

NOTE

The wiring 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.

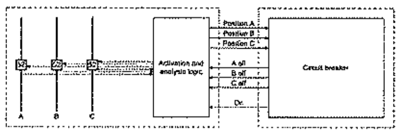


Figure 8-14 Circuit Breaker with 1-Pole Triggering

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).

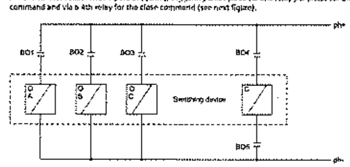


Figure 8-15 1-Pole Connection of a Circuit Breaker

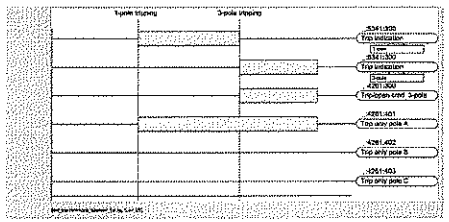
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5
(All)	(All)						
Trip logic	301.5341						
Circuit break.	301.4261						
>Ready	301.4261.500	SPS					
>Acquisition blocking	301.4261.501	SPS					
>Reset switch statist.	301.4261.502	SPS					
>Reset AcqBlk&Subst	301.4261.504	SPS					
External health	301.4261.503	ENS					
Health	301.4261.53	ENS					
Position 3-pole	301.4261.58	DPC					
Position 1-pole phsA	301.4261.459	DPC					
Position 1-pole phsB	301.4261.460	DPC					
Position 1-pole phsC	301.4261.461	DPC					
Trip/open cmd. 3-pole	301.4261.300	SPS	U	U	U		
Trip only pole A	301.4261.401	SPS	X				
Trip only pole B	301.4261.402	SPS		X			
Trip only pole C	301.4261.403	SPS			X		
Close command	301.4261.301	SPS				X	X

Figure 8-16 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 activation 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 5.7.7.3 *Acquisition of Circuit-Breaker Auxiliary Contacts and Further Information*).

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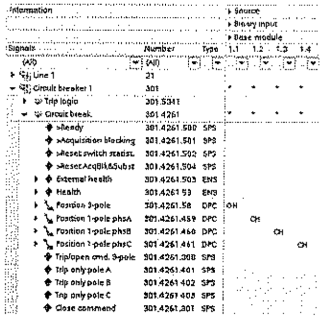

Figure 8-17 Routing of the 1-Pole in DIGSI

The meaning of abbreviations can be found in Table 8-8 and Table 8-9 .

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.

8.2.2.4 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 @ 100 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 100 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 50 Irated	0.030 A to 10.000 A	0.100 A
		5 A @ 50 Irated	0.15 A to 50.00 A	0.50 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	0.100 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	0.500 A
_:2311:136	General:Op. mode BFP		• unbalancing • I> query	unbalancing

Addr.	Parameter	C	Setting Options	Default Setting
Trip logic				
_:5341:103	Trip logic:Reset of trip command		• with I< • with I< & aux.contact • with dropout	with I<
Circuit break.				
_:4261:101	Circuit break.:Output time		0.02 s to 1800.00 s	0.10 s
Manual close				
_:6541:101	Manual close:Action time		0.01 s to 60.00 s	0.30 s
Control				
_:4201:101	Control:Control model		• status only • direct w. normal secur. • SBO w. normal secur. • direct w. enh. security • SBO w. enh. security	SBO w. enh. security
_:4201:102	Control:SBO time-out		0.01 s to 1800.00 s	30.00 s
_:4201:103	Control:Feedback monitoring time		0.01 s to 1800.00 s	1.00 s
_:4201:104	Control:Check switching authority		• no • yes • advanced	yes
_:4201:105	Control:Check if pos. is reached		• no • yes	yes
_:4201:106	Control:Check double activat. blk.		• no • yes	yes
_:4201:107	Control:Check blk. by protection		• no • yes	yes
Switching authority				
_:4201:151	Control:Sw.dev. related sw.auth.		• 0 • 1	false
_:4201:152	Control:Specific sw. authorities		• 0 • 1	true
_:4201:115	Control:Specific sw.auth. valid for		• station • station/remote • remote	station/remote
_:4201:153	Control:Num. of specific sw.auth.		2 to 5	2
_:4201:155	Control:Ident. sw.auth. 1		Freely editable text	
_:4201:156	Control:Ident. sw.auth. 2		Freely editable text	
_:4201:157	Control:Ident. sw.auth. 3		Freely editable text	
_:4201:158	Control:Ident. sw.auth. 4		Freely editable text	
_:4201:159	Control:Ident. sw.auth. 5		Freely editable text	
_:4201:154	Control:Multiple specific sw.auth.		• 0 • 1	false
CB test				
_:6151:101	CB test:Dead time		0.00 s to 60.00 s	0.10 s

8.2.2.5 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
_: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

No.	Information	Data Class (Type)	Type
_: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

8.2.3 Disconnector Switching Device

8.2.3.1 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 und 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:

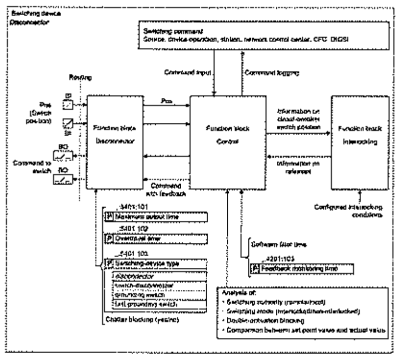

Figure 8-18 Control-Relevant Function Blocks of the Disconnector Switching Device

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 provided 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 in a neighboring bay can be acquired.

Function Blocks of the Disconnector

Table 8-10 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 Overtravel 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 (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 8.2.3.2 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 8-11 Setting positions 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

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Properties	Function	To Be Found In
Spontaneous position changes filtered by (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 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 8-12 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 8-13 Additional Settings in the Device Settings with effect on the Disconnector

Properties	Function	To Be Found In
Number of permissible state changes	Chatter-blocking setting value Once for the entire device	Device settings (to be found under Settings)
Chatter test time		
Number of chatter tests		
Chatter dead time		
Chatter test time		

The inputs and outputs as well as the setting options of the Disconnector switch function block are described in the next chapter (see 8.2.3.3 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 8.2.2.2 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 8.3.1 Command Checks and Switchgear Interlocking Protection.

8.2.3.2 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 matrix 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 (Increment: 0.01 s)
(_:5401:102) Overtravel time	0.00 s	0 s to 60 s
(_:5401:103) Switching-device type	disconnector	switch-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.

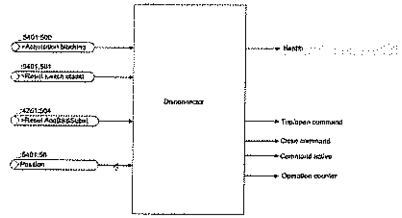

Figure 8-19 Logical Inputs and Outputs of the Disconnector Function Block

Table 8-14 and Table 8-15 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 8-14 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 stability status (Health) of the Disconnector function block is set to Warning.

Table 8-15 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 controls 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[22]) 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, 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).

Settings	Default Setting	Possible Parameter Values
(_:4201:101) Control model	SBO w. enh. security[23]	direct w. normal secur. SBO w. normal secur. direct w. enh. security SBO w. enh. security
(_:4201:102) SBO time-out	30.00 s	-
(_:4201:103) Feedback monitoring time	10.00 s	-

[22] In standard IEC 61850, Reservation is described as Select before Operate (SBO).

[23] The default setting is the standard control model for a switching command in an IEC 61850-compliant system.

Settings	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

8.2.3.3 Trigger Variants of the Disconnector

The activation types are identical to those for the circuit breaker. The meaning of abbreviations can be found in 8.2.2.3 Connection Variants of the Circuit Breaker and 8.2.2.3 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

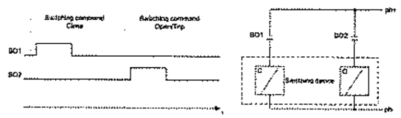

Figure 8-20 1-Pole Triggering

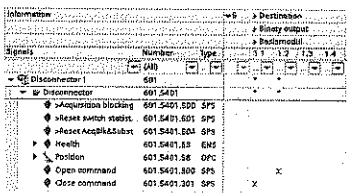

Figure 8-21 1-Pole Triggering, Routing in DIGSI

You can select the contacts for On and Off as desired. They need not necessarily be next to one another.

1.5-Pole Triggering

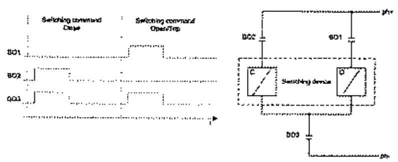

Figure 8-22 1.5-Pole Triggering

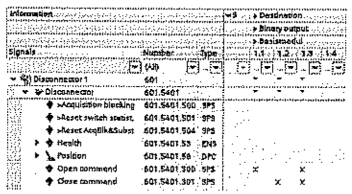

Figure 8-23 1.5-Pole Triggering, Routing in DIGSI

2-Pole Triggering

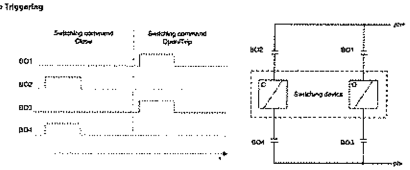

Figure 8-24 2-Pole Triggering

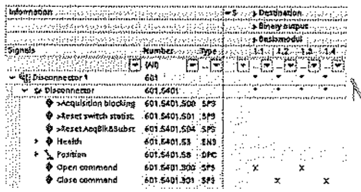

Figure 8-25 2-Pole Triggering, Routing in DIGSI

The feedback is routed via the position within the disconnector.

8.2.3.4 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

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